

University of Sheffield Radar Archive

Ref: MS 260

Title: University of Sheffield Radar Archive: a collection initiated by Donald H. Tomlin, graduate of the University of Sheffield 1940

Scope: Documents, books and offprints on the history of the development of Radar from 1921

Dates: 1921-2005

Level: Fonds

Extent: 46 boxes; 73 volumes; 113 binders

Name of creator: Donald Hugh Tomlin; John Beattie

Administrative / biographical history:

In February 2001 Donald Tomlin presented his collection of documents, including some which he had himself written, relating to the early development of Radar and his own work within the field, to the University Library, a donation which complemented his earlier presentation of books and offprints when he stated: "The collection of books and papers is being presented to Sheffield University in grateful thanks to the University for the training I received in the Science Faculty in the years 1937 to 1940 and which led to a lifelong career working in Radar and Electronics... The books...represent... a cross section of those books available to workers in the new subject of RDF, later to be renamed by our American colleagues RADAR in 1943. The subject of Radar was entirely new as far as practice was concerned, in 1936, and therefore no information was available on the subject. One had to fall back on books on radio, telephony and electromagnetic waves". The documents in this later collection include original papers, copies of significant documents on the history of the development of radar both published and unpublished, some photographs and Tomlin's own memoirs.

Donald Hugh Tomlin (1918-2013) was born in Sheffield and educated at the Central Secondary School for Boys. He showed an early interest in Radio, helping to form and acting as Secretary of a Sheffield 'Short Wave Club'. He graduated in Physics at Sheffield University in 1940, and during his studies proposed, as a potential postgraduate, investigating Radio reflections. His early interest in Radio led to his obtaining an Artificial Aerial Transmitting Licence, which was cancelled with the outbreak of war; however, he was directed by the Joint Recruiting Board to complete his degree, and was then sent to join the ADEE (Air Defence Experimental Establishment) at Christchurch, Hampshire, where work was in progress on experimental RDF (Radio Direction Finding) equipment. In 1941 the establishment was renamed the Air Defence Research and Development Establishment (further changes of name and organisation were to follow over the years), and in 1942, following a successful British raid on a German Radar installation on the Channel coast the Establishment was ordered to evacuate to Malvern, Worcestershire. From November 1940 for the duration of the war he worked on the new magnetron systems, and then on the development of a new 10cm. RDF set, the Anti Aircraft Gun Laying Set, which developed various other applications such as meteorological, mortar location and aircraft 'talk you down' functions. In 1946 work began on an Army requirement for early warning Radar to provide information to gun batteries guarding defended areas. This work later found

application as Air Traffic Control Radar for military aircraft. From 1960 he became involved with a future RAF Air Defence System and the production of a new generation of high powered Radar sets, becoming generally responsible for Ministry of Defence coordination of multi-equipment contracts for the development and production of major Air Defence Systems, and an MOD representative with NATO on a new Radar Control System. After his retirement in 1978 he acted as a consultant, and also as a historian of the early development of Army, and, from 1953, of RAF Defence Radar.

The collection includes three framed photographs, two being of Radar equipment and one of an operating control room.

As a Sheffield graduate, Donald Tomlin took an interest in the Sheffield University Association, and was an Executive Committee member of Convocation from 1985, and a member of the University Court from 1997. He died in December 2013.

In 2015, the Beattie Papers on Civil Marine Electronics were added to the University of Sheffield Radar Archive. The collection of binders containing documents relating to all aspects of civil marine electronics was created by John Beattie, former Director of Decca and responsible for many of their post-war radars and navigational systems, and was transferred to Sheffield by Dr. Phil Judkins of the Defence Electronics History Society after John Beattie's death.

- **Related collections:** None
- **Source:** Donated by Donald H. Tomlin and Dr. Phil Judkins
- **System of arrangement:** Chronological and by subject
- **Subjects:** Radar - Great Britain
- **Names:** Air Defence Research and Development Establishment (Malvern, Worcestershire); Tomlin, Donald Hugh (1918-2013); Malvern (Worcestershire); University of Sheffield - Department of Physics; Beattie, John; Electronics in navigation
- **Conditions of access:** Available to all researchers, by appointment
- **Restrictions:** None
- **Copyright:** According to document
- **Finding aids:** Listed

List of Files

- 1 Radar equation
- 2 Reflectors
- 3 Radar meteorological phenomena
- 4 Radio propagation
- 5 Radar reflections from aircraft
- 6 Aerials, Radar
- 7 Signal/Noise ratio and effects on visual (CRT) displays
- 8 Disclosure of Wartime Radar information
- 9 Guided Weapon Symposium on Defence at RRE May 1956
- 10 Radar development for air defence
- 11 History of Cossor Electronics Ltd.
- 12 Inductances and delay lines
- 13 Mathematics
- 14 Lecture notes
- 15 Account of Army Radar by Prof. J.D. Cockroft
- 16 BTH at War
- 17 Appreciations of the work of Dr W.A.S. Butement
- 18 The role of Metropolitan Vickers Ltd. in the period before and during the War
- 19 Marconi - a War record
- 20 History of GEC by C.C. Paterson
- 21 Cavities, dielectrics, special and coaxial transmission lines, impedance measurement
- 22 Optics, edge lighting and light pipes
- 23 Celebration of 50th anniversary of the Cavity Magnetron on 21 February 1940, held at Birmingham University 21 February 1990
- 24 CH - The First Operational Radar Bruce Neale (Marconi) GEC J o R. 1985 reprint

- 25 CH. (Transmitter T1190) Air Publication 2911 BA
- 26 The Magnetron
- 27 Transcript of interview with Rosemary Preece (Open University project) re 'Early days of Radar in Malvern
- 28 Lecture on 'Impact of Radar on Worcestershire' (D.H.T.)
- 29 Early Radar proposals
- 30 The beginnings of British Radar November 1935 Onwards
- 31 ADEE/ADRDE/RRDE in the War years 1939 to 1945
- 32 Radar development to 1945 (IEE Lecture 1985)
- 33 Searchlights to Radar, the story of anti-aircraft and coastal defence development
- 34 Background to GL3 the UK Centimetric AA Radar
- 35 RRE File list for 'Linesman' Project in RRE Ground Radar Department. Linesman was the RAF Ground Control system for Air Defence 1970 period.
- 36 RRE File list for 'Ground Radar' Department. It also covers some of the files in section 35 above. Main contents cover most of the Research projects in Ground Radar Dept, including those for the Field Army.
- 37 RRE File List for Orange Yeoman Type 82 for the RAF
- 38 Draft of comments (Manuscript) by D.H. T. on 'Watching the Skies' by J.F .Gough (Jack) which describes the post-war Radar System operated by the RAF, and its various stages of development.
- 39 Bawdsey Research Station Manual for the CH station built there. Parts 1 and 2 only. Copies of which were issued to the other pre-war CH Stations.
- 40 Report of Fighter Command Research Section Sept 1941 on the state of RDF in North Scotland and the Isles with an update of Sept 1942.
- 41 Unofficial descriptive notes on RDF1 (CH stations)
- 42 Comments on proposals to improve CH (RDF1) 1952 and 1956.
- 43 Scrap book of Newspaper cuttings - mainly 1945 onwards along with personal notes - relating to Radar, Atomic Energy and Scientific Education. Collected by Dr. D.R. Chick, an early radar scientist at ADEE and its successors to 1947, and then AEI at Aldermaston Court, Vickers Research Centre and Woolwich Polytechnic (later Surrey University)
- 44 Copy of 'My Memories', Donald H. Tomlin 1937 to 40, written as part of the Sheffield University Convocation Archives for the Centenary of the University, 2005.

- 45 Record of the Institute of Electrical and Electronic Engineers (USA) 1985 International Radar Conference
- 46 Index of Radar Equipments, USA, UK (RAF, Army, Navy), German (Army, Luftwaffe). Whilst the listed equipments are mainly Ground Radar, there are some Airborne sets in the RAF list and in the German list..
- 47 D.H.T Lab Book of 1939/40 for the Advanced Physics Lab. at Sheffield University. This is included because, by agreement with Dr. G.T.H. Conn, DHT carried out the 'Magnetron' Experiment of Hull (1921), and also tried to determine some characteristics of a 'soft' valve, using a 'Screened Grid' valve, with gas in it at very low pressure.
- 48 From time to time, as one of the oldest living (2002) of those who worked on Radar for the U.K. Army, 1940 to 1953, and who has maintained the history of Army Radar, and since 1953, has similarly maintained the history of RAF Ground radar, from time to time DHT is asked by retirees or the widows of retirees, to safeguard scientific papers of those officers. This particular set consists of collected papers of Dr. E.K. Williams.
Where such items are small in number, they have been included in the General Deposit, with a note as to source, whereas in this case, there are large numbers of papers, they have been included under a single Deposit number but then broken down into subject files with an added indicator in the Index, viz, File 48 (EKW.1)
- 48 EKW 1 Radomes, aerials, phased arrays, scanning.
- 48 EKW 2 'Chirp', SAW Delay lines
- 48 EKW 3 Eureka / Monica.
- 48 EKW 4 Radar Clutter
- 48 EKW 5 Papers on various Radar Scanners & associated topics.
- 48 EKW 6 Multi-Static Radar
- 48 EKW 7 Notes on IEE Symposium on mm Radar and Sensors
- 48 EKW 8 Air Anti-collision Devices Considerations
- 48 EKW 9 TRE & the Invasion and other Special Forces
- 48 EKW 10 Automatic Strobos
- 48 EKW 11 Aspects of Radar Warfare and ECCM
- 48 EKW 12 Radar Detection in Sea Clutter
- 48 EKW 13 Radar Reflectors for Navigation
- 48 EKW 14 IEE Proceedings 'F', Communications, Radar, Signal Processing

- 48 EKW 15 Lecture Notes on Probability & Statistics
- 48 EKW 16 Bombing Accuracy
- 48 EKW 17 CRT Improvements, Phosphors etc.
- 48 EKW 18 Radar Classification of Ships
- 48 EKW 19 Radar for Castle Martin Test Ranges
- 48 EKW 20 Aspects of Doppler
- 48 EKW 21 Synthetic Aperture Radars.
- 49 Collection of 50 files containing the papers of Professor Kenneth Milne
- 50 "Wurzberg" radar: a detailed description of the German 50cm radar written by Arthur O. Bauer, in German
- 51 GL3. B.T.H.: minutes of development meetings, 1941-1943, "Dr. Warren's File".
- 52 Paterson Papers: papers of Dr. Paterson, head of research at the GEC Research Laboratories at Wembley
- 53 GL3 Monitor Van: used to maintain radar equipment in the field
- 54 EKCO airfield approach radar
- 55 Combined operations, 1940-1942: a "book" issued by the Ministry of Information in 1943 designed to boost morale in the U.K., and including a chapter dealing with the attack on the radar station at Bruneval
- 56 Data Summary and Index of Radar Equipment originally produced by the staff of the School of Anti-Aircraft Artillery, c.1958
- 57 Searchlight Control (by Radar) - SLC - "Elsie"
- 58 Collection of obituaries
- 59 ADRDE/RRDE staff lists for various purposes and times
- 60 TRE (Telecommunications Research Establishment) staff chart
- 61 Air Defence Experimental Establishment- Early papers of historic value
- 62 Radar Anti-Jamming techniques
- 63 Radio Instruments and Measurements (U.S. Bureau of Standards, March 1924)
- 64 London Electrical Engineers, Territorial Army
- 65 "Search Light" March 1915-March 1916

- 66 "Search Light" April 1916-September 1916
- 67 "Search Light" October 1916-October 1917
- 68 Article by Dr. Bowen on 'The History of the Development of Radar. Part 1', Sydney, 7th February 1946
- 69 Correspondence between Donald Tomlin and the editor of 'Transmission Lines'
- 70 Data on the parameters of Radar Approach Radars and surveillance systems
- 71 *The Birth of British Radar*. The memoirs of Arnold (Skip) Wilkins, edited by Colin Latham & Anne Stobbs (publ. by DEHS, 2006)
- 72 SD0458 Ground Radar Stations, RAF AMES Type 1 (photographs)
- 73 Shore Radar Services, AP2275E & CD0911 (photographs)
- 74 SD0458/AP2276 (Copy 125 Aug 1943) Photo record of Radar Ground Stations
- 75 Loose photographs of an RAF convoy, mustered for testing at TRE Malvern before going to France, 12 June 1944. Other photographs of individual equipment
- 76 Interservice electronic valve specifications. Part 1
- 77 Interservice valve specifications. Part 2: semiconductors
- 78 RCA electronic valve specifications. Book 1
- 79 RCA electronic valve specifications. Part 2
- 80 Photographic information and data books
- 81 Proximity fuses
- 82 Essay on British naval development
- 83 Correspondence between Bill Melville & DHT re. photograph
- 84 Correspondence between Bruce Neal (Marconi Radar Systems) & DHT re. book on Baird's connection with radar
- 85 Correspondence between Van der Hulst & DHT
- 86 Odd papers and letters (Bill Melville, Bruce Neal, Tom Pippitt)
- 87 Correspondence between Squ. Leader Frank Hayward, historian of RAF Christchurch and the Trials Flying Unit, & DHT
- 88 Correspondence between Ian Shaw (Glasgow) & DHT
- 89 Pamphlets about Christchurch, Steamer Point and other points in the district around the Somerford ADEE site

- 90 Papers from the late Professor P.D.L. Williams (PW1-PW9)
- 91 Potted history of the events leading up to the development of GL3 anti-aircraft radar for the British Army
- 92 Series listing of ADEE/ADRDE/RRDE official technical photographs
- 93 Papers relating to Trevor Simpson Moss (TSM1-TSM10)
- 94 Papers relating to GL3 radar equipment: GL RADAR 1: History: Subfile 1: Early history
- 95 German searchlights (Heinrich Beck Institute)
- 96 'One story of radar' (Book)
- 97 Correspondence between R.G. Stansfield (Operational Research Society) & DHT on the origin of operational research
- 98 Pamphlet by the late Ernest Putley, 'Science comes to Malvern: TRE, a story of radar 1942 to 1953'
- 99 'The First Step' (mounted print of painting by Roy Huxley)

Addenda

Royal Air Force Air Defence Radar Museum - Newsletter

No. 44- (August 2005-)

Transmission Lines (Defence Electronics History Society)

Vol. 10 no. 2- (June 2005-)

Photograph of Donald H. Tomlin (B&W)

Audiocassette of the speeches made at the Inauguration of the University of Sheffield Radar Archive, 21st October 2005

Autobiographical notes by Kenneth Hopkinson, graduate of the University of Sheffield 1931, and employed at the Royal Radar Establishment until c.1972

Wood, Harry O. & Neumann, Frank, 'Modified Mercalli Intensity Scale of 1931', from Bulletin of the Seismological Society of America, 1931-1932. Printed, 7 1.

3 Photographs (framed), with descriptive background

SLI 13 Radar GL3/CMH Model A'0'. BTH Research Laboratories, Rugby. 30 May 1941

SLI 14 Radar Type 82. Radar Head, RAF Lindholme. 29 Mar 1978

SLI 15 Radar Type 82. Control Room, RAF Lindholme. 29 Mar 1978

The Lindholme photographs were taken just before the closedown of the site on 31 Mar 1978

FOLDER FILES Containing Reports & Offprints of Articles & Documents on Specific Subjects

(1) RADAR EQUATION

Contents:

1/1	The Radar Equation	<u>Electronics</u>	April 1945
1/2	Factors affecting Radar Range	<u>RCA</u>	1943
1/3	'Radar Evening'	<u>I.E.E. Rugby Student Section</u>	1948
	Contains 4 sections	(a) Principles of Radar – scope and limitations	
		(b) Aerials & Waveguides	
		(c) The Magnetron	
		(d) Modulator	
	Unfortunately the copies of figures referred to in the text are not reproduced.		
1/4	Radar Performance Nomogram (card)		
1/5	The Maximum Range of a Radar	Norton & Omberg <u>Proc IRE</u>	1946
1/6	The Maximum Range of a Radar	Comment/discussion <u>Proc IRE</u>	1947
1/7	Resolution in Radar Systems	Freedman <u>Proc IRE</u>	1950
1/8	Radar	Schneider <u>Proc IRE</u>	1946
1/9	Technical & Tactical Features of Radar	De Witt <u>Proc IRE</u>	1946
1/10	Radar System Considerations	Quarles <u>Trans. AIEE</u>	1946

(2) REFLECTORS

Contents:

2/1	Radar Echoing Power of Conducting Spheres	Pearcey & Scott	<u>ADRDE Res Rpt 228</u>	1944
2/2	Targets for Microwave Radar Navigation	Robertson		1947
2/3	Scattering of CM Waves by conducting spheres, discs, cylinders	Hey, Pinson, Prince	<u>RRDE Rpt 375</u>	1953
2/4	Microwave Radar Reflectors	<u>Radiation Lab Rpt. 43-23</u>	MIT	1943
2/5	Radar Reflectors	Original disclosure to USA of use of 'Corner Reflectors'		June 1942

(3) RADAR METEOROLOGICAL PHENOMENA

Contents:

3/1	Charts of Dielectric Constant of Atmosphere	A. W. Friend RCA	<u>Bull Am Met Soc.</u>	1948
3/2	Theory of Radar Echoes from Meteors	McKinley & Millman	<u>Proc IRE</u>	April 1949
3/3	Effect of Rain & Fog on Very Short Radio Waves	Stratton	<u>Proc IRE</u>	June 1930
3/4	Radar Storm Detection	Wexley & Swingle	<u>Bull Am Met Soc</u>	1947
3/5	Attenuation of Radar echoes at Cm. Wavelengths by various meteorological Phenomena	Ryde (CEC)	<u>Met Soc Rpt</u>	c.1947
3/6	Radar Detection of Frontal Storm	Wexler	<u>Jnl Meteorology</u>	1946
3/7	Radar & Weather	Com. Maynard	<u>Jnl Meteorology</u>	Dec 1945
3/8	Radar & Weather	Discussion of above	<u>Jnl Meteorology</u>	Sept 1946
3/9	Radar Detection of Precipitation	Bent	<u>Jnl Meteorology</u>	June 1946
3/10	Attenuation of Radar echoes at Cm. Wavelengths by various meteorological phenomena	Ryde	Lecture at IEE Radiolocation Conv.	27.3.1946
3/11	Solar Outburst at 600 Mc/s & 1200 Mc/s	Lehany & Yabsley	<u>Nature</u>	1948
3/12	Rainfall Intensity & Attenuation of Cm Waves	Wexley & Weinstein	<u>Proc IRE</u>	1947
3/13	Radar Range/Height Charts	American Def. Doc. Centre		
3/14	Various Range/Height Charts			
3/15	Investigation of Atmospheric Phenomena affecting 1200 Mc/s Region (L Band)	D.H. Tomlin	<u>RRDE Report 347</u>	1949

(4) RADIO PROPAGATION:

Contents:

Propagation of Radio Waves

4/1	Around the Earth	Bremmer	Philips Labs. Eindhoven	1948
4/2	Effect of Multipath Reflections on height finding	Fante, Franchi, Taylor	Rome Air Centre N.Y.	1976
		RADC Rpt TR76-379		
4/3	'Lympath' Progr. for Reflection, Diffraction & Propagation Analysis	Clark	Farinon	1978
4/4	Study of Radar Elevation Angle Errors due to Atmos. Refraction	Fannin & Jeyn	IRE	1956
4/5	Experimental Investigation of Propagation of 2 & 3 Metre Radiation	McPetrie & Saxton	IRE	1939/40
4/6	Reflection Curves & Propagation Characteristics of Radio Waves along Earth's surface	McPetrie & Strickland	IEE	1939
4/7	Propagation of Wireless waves round the Earth	Balth, Van der Pol, & Bremmer	Philips Tech Rev	1939
	(Contains other articles)			
4/8	Experimental Investigation of Reflection & Absorption of 9cm Radiation	Ford & Oliver (NPL)	Proc Phys Soc 58(3)	1945
4/9	Atmospheric Effects & Height Data Calculations	Barker (Plessey)		Feb 1979
4/10	Radar Multipath Phenomena	Barton	Micro Wave Jnl	1976

(5) RADAR REFLECTIONS FROM AIRCRAFT

Contents:

- 5/1 Characteristics of 'S' Band Radar Echoes
with Particular Reference to
Radar AA. No. 3 Mk2 (GL/) Beeching & Corcoran ADRDE Res Rpt 253 1944
- 5/2 Characteristics of 'S' Band Radar
echoes (Extension of above to
Jet Aircraft (Meteor) Beeching RRDE Report 326 1946
(Interim Rpt on Aircraft echo)
- 5/3 Characteristics of 'L' Band
(1200Mc/s) Tomlin & Merrifield RRDE Tech Note 34 1948/49

(6) AERIALS, RADAR

Contents:

- 6/1 Directional Aerial Systems R J Clayton & D O Hughes (GEC) 27 Sept 1940
(Deals theoretically with properties of a number of aerial types. Used regularly as a quick reference. Written at time GEC were involved in design of early A.I. equipments)
- 6/2 Radar Antennas Friis & Lewis Bell System Tech Journal April 1946
Reprint.
(This is the published version of a document originally circulated in 1941, following the Tizard Mission to the USA)
- 6/3 Directional Aerials Brown Part of a paper in Proc IRE Vol 25 1937
(A little known treatise on directional aerials, but on which much of the early work on Radar Aerials was based by a few of the workers in the field. Brought to DHT's notice by Ashmead, the ADRDE Head of Aerial Design, in 1943. He had discovered it only shortly before)
- 6/4 Metal Plate Lenses Winston K. Kock (Bell) Proc IRE November 1946
- 6/5 Path Length Microwave Lenses Kock (Bell) Proc IRE Aug. 1949
- 6/6 Horn Feed for parabolic aerial Rad. Com. March 1975
- 6/7 An X-Band Model Receiving aerial for 'Orange Yeoman' Radar
Milne (BTH), Boys (MV), Brewitt-Taylor (RRDE)
BTH Engineering Rpt ER 3706-8 4 Jan 1952
- 6/8 Electrical Tests of Type 800 Mock up Radar receiving aerial.
Whellans & Smith (MV) Brewitt-Taylor (RRDE)
M.V. Eng Rpt 4004-S June 1953
(Type 800 was the internal designation at MV Co. of 'Orange Yeoman', later RAF Type 82.)

The lens aerial was adopted for Radar Type 82, because lenses gave better symmetry of narrow beams off axis, which property could be used to provide a means of measuring elevation by comparing signals in adjacent beams.

(7) Signal/Noise ratio and effects on visual (CRT) displays

From the earliest days of Radar, as in all forms of communication, the amount by which a wanted signal exceeds the unwanted noise background, no matter how this is caused, has been an important factor in determining whether the wanted signal could be interpreted.

With radio and radar, such noise background might be collected by the aerial although this factor might generally be small, generated by the circuits which pass the signals from the aerial right up to the user output. Each stage which operates on the signal adds its own bit of noise, and where a stage amplifies, it operates on all the noise from previous stages, so that it can be seen that the earlier stages are the most crucial, and should be designed to generate as little noise as possible.

Unfortunately, the final noise count is what affects the final user most.

These papers in various ways, describe the effects of such noise.

Contents:

- 7/1 Interim Report on 'Visibility of signals in noise and dependance on parameters of Radar equipment E.R. Andrews & Brenda A Langford.
ADRDE Research Report 207 15/7/1943
(Note: In 1946, Brenda Langford went to Canada, and became a foremost Research Psychologist)
- 7/2 Combination of signals and noise from a number of receivers and the effect on sensitivity H. Gaunt, J.G. Milner, A.E. Bailey ADRDE Report 342 29/7/1948
- 7/3 PPI display problems when signals are collected from a number of sources:
General Problem D.H.Tomlin (RSRE)
Sector video gating I.C. Newman (MRSL)
Monitoring and setting up videos throughout a Radar System, with video from a number of sources A.W.F. Cushing (MRSL)
The Air Defence Centre, Monitor Complex A.W.F. Cushing (MRSL)
This is a collection of papers presented to MOD and Fighter Command in 1975.

The ADGE system referred to was discontinued in c1986 and the original classification is no longer necessary.

(8) Disclosure of Wartime Radar Information

It must be appreciated that during the 1939-45 War, as before, from 1935, the very existence of radar was not disclosed, except for two particular cases, the first in the UK and then worldwide, and the second in the USA.

The first on 18 June 1941 was in a broadcast by Lord Beaverbrook, at the time, the Minister for Information. He spoke, without giving any details, of the UK having a means of detecting aircraft by Radio. The purpose of the disclosure however, was to reach as many radio technicians or others technically qualified, as possible, to get them to volunteer to join a 'Maintenance Corps', i.e. to form a body of qualified persons with knowledge or skill in radio. The resultant influx included large numbers of Physics Teachers and pre-war radio amateurs, and it also resulted in a number of people already in the Forces, being transferred to Radar Maintenance duties.

The second event was the publication on 2 July 1943 in the USA of a document intended for Members of Congress, who had been showing disquiet at other countries being in advance of the States in this new technology. This document inevitably emphasised the American connection.

One other publication of significance was the MIT Radar Engineering Handbook written for the express purpose of training the many technicians who were drawn into the Massachusetts Institute of Technology 'Radiation Laboratory'. Originally for internal use only, a later version was produced and sold openly. I had a copy of the original book, brought from MIT in 1943 by a US Army Captain, who was one of the American Liaison Officers stationed at ADRDE, Malvern. Unfortunately I replaced it with the later version, because this had extra sections, more up to date.

However in the days immediately following the fall of Germany, discreet articles began to appear in the popular press, giving some information about the role of the Ministry R & D Establishments, and then following the capitulation of Japan, there was a flood of pre-prepared information released to the Press. All shades of newspapers covered their main pages with the information, which was about more than Radar, such as Proximity Fuses, Magnetic Mine detection etc.

The Technical Press picked up the Radar story and many articles on specific subjects as well as general topics appeared, some rather inaccurate. In consequence it was decided that a full disclosure of all the aspects of radar should be made, and in consultation with the IEE, it was decided that a 'Convention' should be held, giving anybody with useful information, a platform to speak. The Convention was held over a period of time from March to May 1946 at the IEE, and some 100 lectures were given ranging from a history of the beginnings of Radar, through to complex circuit developments. The papers were however heavily vetted both at Ministry level and by Referees who in many cases had no idea of the importance of some of the 'deeper' papers.

The venue at the IEE however brought to prominence many from TRE, RRDE, and the Naval Signals School, as well as many from industry.

Basically it was a British disclosure, but there were representatives from abroad, particularly from the USA and Canada. The result however was to stimulate the MIT to publish a multi-volume series of books on the subject, again with scant mention of anything other than American.

The resultant papers from the Convention were collected together and published as Journal of IEE Volume 93 Part IIIA (Radiolocation) No. 'X' 1946. The number of parts ran to 24(?), and even today are much sought after by Radar historians, and form the basis of our understanding of the techniques available and used from 1936 to 1945.

Contents:

- 8/1 IEE Proceedings Vol. 93 Part IIIA No. 7, 1946. (The Part contains an index)
- 8/2 'Checking the angular accuracy of a precision fire control radar'
G.H. Beeching (RRDE) IEE Journal Vol. 93 Part IIIA
(part of No 2) 1946
(Reprint of article only)
- 8/3 Transcript of the BBC Broadcast of 18 June 1941, along with subsequent articles in 'The Times' and 'Daily Telegraph', with BBC covering letter
- 8/4-5 'The Story of Radar'. US Senate paper 2 July 1943. Original moth-eaten copy and good copy

(9) Guided Weapon Symposium on Defence at RRE May 1956.

Contents:

9/1 A collection in one volume, of papers outlining problems and suggested solutions re control and correlation of G.W. Systems.

Contents list of 25 subjects is contained in the volume.

(10) Radar Development for Air defence

Contents:

A 'popular' article on post war Air Defence, following the open disclosure of the UK G.W. Air Defence system and its control radars.

(At that time D.H. Tomlin was involved in the long term development of 'Orange Yeoman' Radar, and its Tactical Control Centre (Later RAF Type 82), and the overall integration of input data from remote radars, and the dissemination of control data to Putting On Radars and the Guided Weapons)

10/1 Reprint of article from Communications and electronics, by RRDE Staff Feb 1959

(11) History of Cossor Electronics Ltd.

Contents:

11/1 'The First 50 years of Radar' Alfred Price (Cossor Ltd) 1985

(Note: Cossor built the AA No 2 Mk1 (GL1) Receiver system, in time to have a small number of sets in the Field at outbreak of the war. They had no connection with AA No 2 Mk2 (GL2), but by accident Price picked up the GL2 pictures for both the front cover and Page 10. The Mk2 receiver system was designed in conjunction with ADEE and built by EMI under the close control of Edward C. Slow of ADEE)

(12) Inductances and Delay lines

Artificial Delay lines came into prominence when EMI was designing the electronic circuits for the London 'High Definition' Television station in 1936. They were used for accurately producing many of the pulses which set the levels and timing of traces, blanking pulses, line and frame synchronising pulses and video.

Subsequently extensive use was made of lumped constant artificial delay lines by EMI and BTH in Radar Transmitters, for determining pulse lengths and shapes. They were also used in precision test gear where stable timings were required.

In Radar receiver design, mutual and self inductance of coils in the tuning circuits had to be optimised in order to give the best performance of the valve interstage couplings, and to preserve pulse shapes in high gain video stages.

Contents:

12/1	Mutual Inductance	Maddock	<u>Wireless Engineer</u>	1945 (1)
12/2	Video Delay lines	Blewett	<u>Proc IRE</u>	1947 (2)
12/3	Artificial Delay lines	Trevor	<u>Electronics</u>	1945
	Similar to Blewett's paper, but concentrating on lumped constant lines			
12/4	Computing inductance of wires	Stephen	<u>Communications</u>	April 1946
	A statement of a long standing problem, but reduced to a nomogram.			
12/5	Double tuned Transformer Design	Esply	<u>Electronics</u>	Oct 1944
	A condensation of techniques used to design inter valve transformers for radio circuits			
12/6	Design of pulse forming delay lines	D.H. Tomlin		1941
	A collaborative paper produced as the result of discussions between DHT (ADRDE) and W. Melville (BTH) and taking into account data which came from Trevor (above). Melville designed the delay lines used in the gL3 Transmitter in 1940/41. This paper circulated widely at ADRDE and among modulator designers in Radar Firms.			

Notes:

- (1) This is a published version of a paper commissioned from Maddock in 1942 by ADRDE when consideration was being given to designs for high voltage pulse transfer transformers for 1-2 microsecond pulses, from 350 volts to 20KV, and also using variometers as voltage control elements for pulses.
- (2) A published version of several papers circulated through MIT during the War. This paper concentrates on continuous wound coaxial cable lines rather than lumped constants.

(13) Mathematics

Many of the research workers at the Radar Establishments were not deeply mathematics literate. The pre-war Engineering and Physics Schools, and even more so Chemistry Schools, of the Universities did not include in depth mathematics training, but concentrated on the factual teaching of the main subject. Consequently, when faced with 'practical' physics or engineering requiring mathematical agility, on the job maths training was necessary. (Before the War, Physics schools might only boast 3 to 5 and often 1 only Physics Honours Students, and the number of graduates going on to higher research degrees was miniscule. They spent part of their 4th year studying Maths.)

In the WW2 Radar sphere, involving mainly physicists, and a small number of engineers, mathematical ability particularly came in useful in such as time delay networks, pulse shaping circuits, servo design and control circuits. When therefore any special reports appeared as a result of other people's experiences, note was taken and data stored. Many of the papers here are reprints of War time data presented to learned journals after declassification of original work.

Contents:

- | | | | |
|------|--|-----------------------|----------------|
| 13/1 | Video Amplifier Design (Practical application of simple maths) | | |
| 13/2 | Transient Response | <u>Proc IRE</u> | March 1945 |
| 13/3 | Transient Response Calculations - Operational Calculus Methods | <u>Communications</u> | Feb 1943 |
| 13/4 | Graphical Solution of Quartics | <u>Machine Design</u> | June 1950 |
| 13/5 | Fourier Series for several Pulse Shapes | <u>Proc IRE</u> | Nov 1945 |
| 13/6 | Number of observations leading to 't'-test of significance of means or differences | 'Research Supplement' | Source unknown |
| 13/7 | Notes on Exponential Distribution in Statistics* | | Source unknown |

* This paper was used for a long time as describing many maintenance problems in complex electronics using several thousands of valves (such as computers- cf Enigma) until it was realised that life of valves was mainly dependant on the mode of usage of valves.

(14) Lecture Notes

In October 1940, it was decided that an entirely new look was necessary for the training of maintenance officers for Radar equipment. This had previously been treated as simply wireless, and did not take into account the complexity of 'computer-like' electronic pulse circuits. The RAF and Navy did extend their radio courses to take the new requirements into account, but the Army produced a new strategy, forming two school groups.

(1) Intended for existing radio officers, and lower ranks, who would form the basis of a new maintenance facility, along with new recruits drawn from 6th form school leavers, existing civilian radio mechanics and school teachers. This special school was set up at Petersham, mainly under the control of civilian lecturers.

(2) For University Graduates, physicists and engineers mainly, who might follow on from those in the first type of course, or might be sent to Government Radar Design Establishments, or to industry working on radar. This course was at the Military College of Science.

In practice, many did both courses, and many, who were graded by the Universities from whence they came as not requiring further training, did neither course.

The MCS wrote up elegant course notes, which the students used. In practice both courses tended to cover the same ground, but with different emphasis. Thus Transmission lines, delay lines and filters appeared prominently, whilst there was no mention of radar transmitters and receivers, although aerials were covered without any reference to their uses in pulse transmission. In other words the courses could equally have been aimed at Communications.

DHT's Section at ADRDE (Christchurch) received two students at about the same time in 1941, one who had been to Petersham (Robson) and one to MCS (Woollen) Both donated their course notes to DHT on leaving the Establishment in 1945/6.

Within the establishments (TRE & ADRDE) after moving to Malvern, organised courses were run by some Senior Staff for the benefit of any of the mid/senior staff who considered they could benefit therefrom.

Contents:

- 14/1 J.M. Robson hand written Petersham Notes
- 14/2 W.B. Woollen hand written MCS Notes. (Woollen, Sheffield Engineering Graduate)
- 14/3 Military College of Science: Notes on Measurements and Instruments
- 14/4 D.H. Tomlin ADRDE & TRE course. Notes on pulse application to tuned circuits

- (15) Account of Army Radar by Prof. J.D. Cockcroft (Chief Superintendent ADRDE from Jan 1941 to July 1944)

Written July 1945.

This account was written whilst Cockcroft was in Canada, where he was supervising the construction of the Canadian Atomic Energy Establishment at Chalk River. It represents very much his recollections, away from the sources of corroborative information, and covering such a wide field, inevitably contains some errors, mainly of facts, although I hasten to add that Cockcroft had an amazing memory. The paper has from time to time been copied in parts by others, and the errors have been perpetuated.

In 1985, the paper was reproduced by the IEE in their Proceedings A, Special Report which contained several early papers on Radar of special importance. DHT pointed out some of the errors, but the IEE decided that they would publish all the papers without any vetting.

The original paper was never published in its own right, but there were a few copies, one in a RRDE File, and at least one in Min of Supply Files in London. All the later versions are copies taken by individuals of those originals.

See also 'Cockcroft & the Atom', Hartcup & Allibone, in the Radar Books section. This carries many of the errors, and a detailed letter to Allibone pointed this out. This was deposited at Churchill College Archives, along with the original book. The original correspondence with Allibone and a copy of the comments, which are very relevant to understanding Cockcroft's paper are included here

In later 1945 Bernard Newsum took exception to Cockcroft's paper, and attempted to 'correct' it to his own ideas. Several of his comments arise due to his misreading the original, and putting emphasis where it did not belong. He also tried to put his point of view of what ought to have been done, without recognising why things legitimately were not done, or could not be done in the time scales available. An example is his desire that Auto following should have been fitted to GL3 from the start. In fact a version was designed within the first year of GL3 being designed, (by MV Co. at Sheffield) which proved quite useless when tested live, and time had by then run out to incorporate a system in the production equipments. It would have taken a very large number of engineers/ physicists to do the job, and these were just not available. The USA did in fact go straight to Auto follow for their 584 equipment, but used over 400 engineers to do it. The UK only had a maximum of 23 members of the GL3 team at ADRDE, and 19 development engineers at BTH, with 7 at EMI, all fully committed designing the main equipment.

Many of Newsum's comments are again recollections, without access to papers.

Contents:

15/1	General Account of Army Radar	Prof. J.D. Cockcroft	July 1945
15/2	Notes on above	B. Newsum	late 1945
15/3	Notes on both the above in letter to IEE	D.H. Tomlin	18 August 1985
15/4	Notes on Cockcroft and the Atom, along with correspondence with Allibone		1985

(16) BTH at War

An extract dealing with Radar only, from a wider publication by BTH after the War, part of a Presentation to the Royal Commission on Inventions for Award Payments.

BTH was the first Contractor to be awarded a contract to design and build a new Centimetric Radar, in October 1940. The original intention was to use a Klystron transmitter valve which had been developed in the Birmingham University Physics Dept, alongside the Cavity Magnetron. By December 1940, it had become obvious that the Cavity Magnetron was the better valve, and BTH changed the equipment design to use it by February 1941. The first working model (A'0') went to Christchurch, ADRDE for trials on May 31 1941, and prototype production was under way of the production 'B' Model version by the end of 1941.

The success of the CL3 was however dependant on obtaining more than the 10 KW of RF power available from the GEC magnetrons, and BTH took on the development and produced 250 KW valves by the end of 1941, having attained 100KW by May 1941. By 1945 they were producing 1 MW valves (BM835)

During the whole period BTH were manufacturing valves and Radar equipments, they used an order book terminology which stemmed from the earliest Radar days, when (a) they made some special valves for Prof Oliphant at Birmingham University, 'VFO' (Valve For Oliphant). The term stayed for internal order numbers for valves; (b) the first radar equipment A'0', referred to above, was likewise referred to at BTH as 'SFO' (Set For Oliphant), since the original intention was that this particular set would initially go to Oliphant at Birmingham for further research. He gave up the idea in recognition that they must press on with urgent evaluation. All BTH Development models of radars were designated 'SFO'; (c) BTH perpetuated the connection with Birmingham in that all the production magnetrons they produced for the wider market (they produced almost all the high power valves during the War) were labelled 'BM * * *' denoting 'Birmingham Magnetron'.

Contents:

16/1 'BTH at War' Part only

BTH

1946

(17) Appreciations of the work of Dr. W.A.S. Butement

These are not obituaries, although one of them was written after his death, by the same person who had written the official Obit.

Butement along with P.E. Pollard were the two officers at the UK Signals Experimental Establishment at Woolwich (Pollard almost immediately went to ADEE at Biggin Hill) who put forward the idea of using short wave radio to detect objects, particularly ships, as a means of providing Coastal Defence. They wrote the idea up in the War Office Inventions Book, but the idea was rejected by the R.E. Board. They did in fact produce a demonstration, but the Board didn't even attend.

Both officers became involved in the War Office Investigation party at Bawdsey in 1937, observing and assisting with the Air Ministry Research station experiments. Butement then concentrated on the design of the first Coast Defence Radar, and Pollard on an Anti-Aircraft Gunnery Radar. They were to become the appropriate section leaders at the ADEE at Christchurch. Butement spent most of the later War period at London HQ, followed by Pollard around 1944.

Butement was later heavily involved in Guided Weapon Development, and went to the Woomara Test Site in Australia. He later became the First Chief Scientist For Defence in Australia.

Contents:

17/1 W.A.S. Butement First Chief Scientist for Defence

17/2 'The remarkable work of W.A.S. Butement' Despatch (Journal of NSW
Military History Society)

(18) The role of Metropolitan Vickers Ltd in the period before and during the War

This is an extract from a booklet issued around 1950, mainly for shareholders of MV and for senior staff employed at the factories.

The Text leads one to believe that MV played a big part in the development of Radar before and during the War. This is not strictly correct. They produced a large amount of equipment, but the design was mainly carried out elsewhere. They were responsible for the development of the valves which really made the Chain Radars possible, but they were designed not for that purpose, but for the BBC, but seen by Chain workers and seized upon for their transmitters. (See Burch Obituary)

Contents:

18/1 The Role of MV Co Ltd in the War Effort. M.V. Co. Ltd.

(19) Marconi -- A War Record

Marconi were only marginally involved in Radar Design in the War Years.

They were in fact fully committed in Radio Transmission and Receiver Design and production, especially for the Navy and Merchant Navy, and also for RAF and Army, to such an extent that it would have been impossible for them to have changed over to Radar without major disruption.

Their Valve Department was however very much involved in the production of microwave and decimetric wave valves, following designs of GEC and (for high power magnetrons) BTH. They also followed BTH in producing quantities of microwave crystal detectors.

Contents:

Marconi -- A War Record

Marconi Co Ltd.

(20) History of GEC

This paper is a General History of GEC, but doesn't mention the wartime activities. It is probable that Paterson (Head of Research Laboratory at GEC) was cautious of security and didn't include them. Equally possible was that he didn't want to preclude later Patent applications.

Contents:

History of GEC

Paterson

GEC

(21) Cavities, Dielectrics, Special and Coaxial Transmission Lines, Impedance Measurement

It must be appreciated that at the outbreak of the War, there was virtually nothing researched or written about properties, procedures, equipment, instruments for any wavelengths lower than 5 metres (60 MHz), and only a small amount for 5 to 12 metres (60 to 25 MHz). Those thrown into working on 50cms (600 MHz) and by late 1940 on 10cms (3000 MHz) were on their own. Before useful measurements could be made at RF, suitable Test Gear had to be designed. Often the main object and test gear went in parallel.

Within the firms and Establishments involved there was a fairly constant flow of information as techniques were evolved, and internal memos appeared on quite narrow subjects, or theoretical and practical experience treatises became available, but the information was jealously guarded to prevent leakage.

After the War, much of this information was published in either volumes covering wider issues, or as single papers on discrete subjects.

There were occasional papers early in the War, which were published in learned journals, before the importance of the subject was recognised. These slips ceased about late 1941.

The papers here are an amalgam of early War published and unpublished origin, and post war 'catching up' articles and papers.

Contents:

21/1	Impedance and other parameter measurements at centimetric wavelengths	Manifold et al	1940/41
21/2	Resonant Cavities	Giacolette	<u>Electron Industrie</u> 1946
21/3	Curves relating to critical lengths of coaxial cable	TRE	1941
21/4	Hybrid Ring Convertors for 70cms (a practical application)	L. Williams	<u>Rad Com</u> 1975
21/5	Magic 'T' Waveguide junction	Saxon & Miller	M.V. Co. 1948
21/6	Instruments for the Microwave bands (Conference paper on Electrical Instrument Design)	Harvey (TRE)	<u>IEE</u> 1951
21/7	Resonance Wavemeters 1000 to 2500 MHz (one of the many papers releasing results of wartime research)	Essen	<u>IEE</u> 93A 1946
21/8	Propagation of E-M Waves in Transmission Lines	Clayton (GEC)	1941
21/9	Use of Waveguide for measurements of microwave * Dielectric Constants	Lamont	June 1940
21/10	Theory of Resonance in microwave transmission * lines with discontinuous dielectric	Lamont	June 1941

* These two papers were used extensively when dielectric insertion between transmission lines was used to induce phase changes in lines, to 'shorten' lines for radar beam swinging.

(22) Optics, Edge lighting and Light Pipes

The principle of edge lighting is an old one, but the means of deploying it has only become feasible from just before the 1939 war. The main requirement is a sheet of transparent material of high refractive index and very low attenuation of visible light. This became available in the 1930s as Perspex (ICI in UK) Delapont (Du Pont in USA) and it was used for many purposes during the war. The strength and clarity led to its use in moulded aircraft cockpit canopies, in flat sheet for information displays and as rods for projecting illumination at selected spots.

DHT first introduced it in Army Radar equipments (GL3), where it was used in special applications to transfer light from a source to a group of instrument indicators, where the use of local lamps would have been intrusive of functional space. The RAF used it from early War for large vertical plotting boards, where fixed information was engraved on one side (the viewing side, and which glowed brightly) whilst transient information on aircraft location and data on the raid, was plotted in reverse by trained operators on the rear using soft wax pencils (Chinagraph). This technique was used so that several plotters could operate simultaneously without any of them obscuring the board from the Senior Controllers. Similarly in the Navy, plotting boards were used in control rooms and instruments illuminated without affecting night adaptation.

In 1938, at a Sheffield University Physics Department 'Conversazione', there was a demonstration of the illuminated board technique, and that is how DHT came to incorporate the system in the control panels for a GL3 modification equipment.

The Light Pipe technique was the fore-runner of optical fibres.

Contents:

22/1	From Edge to Wedge lighting	M.A. Ulbrich (Sylvania)	
		<u>Illuminating Engineering</u>	Feb 1945
22/2	Guided Wave Optics	A. Yariv	
		<u>Scientific American</u>	Jan 1979
22/3 & 22/4	2 photographs (photocopies) of plotting boards in RAF Convoy 70 (a Mobile Radar complex of several mobile Radar sets, with display systems in several cabins and the main control area in a large marquee with aircraft control positions and Senior Controller positions.)		
	This was erected and tested at TRE on the Malvern Boys College Playing Fields in May 1944 prior to its transfer to France after the invasion.		

- (23) Celebration of 50th Anniversary of the first operation of the Cavity Magnetron on 21 February 1940, held at Birmingham University 21 February 1990

Contents:

- 23/1 Sundry correspondence before the Symposium
- 23/2 Arrangements for the Symposium and Exhibition
- 23/3 Sundry correspondence after the event
- 23/4 List of Attendees and arrangements for the Celebration Dinner
- 23/5 Booklet for the Anniversary
- 23/6 Exhibition Catalogue
- 23/7 Text of the lecture on Army Radar by D.H. Tomlin (Note: Not the whole of the paper was given. The full text had been delivered at the IEE in 1985, the 50th anniversary of the decision to embrace Radar in the UK) (No illustrations)
- 23/8 Booklet EEV (English Electric Valves) Magnetrons.
- 23/9 Proceedings of the Symposium
- 23/10 & 23/11 2 photographs of Dr. Lovell and D.H. Tomlin (Display Photograph is the Gun Laying Equipment GL3 Prototype A'0' taken in front of the BTH Research Labs in Rugby on May 30 1941 , as it was made ready for transit to ADRDE in Christchurch, where it arrived 31 May, and was in operation there for trials at 15.00 that day)

(24) CH - The First Operational Radar

This is a reprint of an article by the late Bruce Neale in the GEC Journal of Research, on the occasion of the celebration of 50 years of Radar in 1985 (or more correctly, of the decision to build radars for the defence of the UK)

The equipment described is the original wartime system, before the rebuild in 1950-55.

Contents:

24/1 CH - The First Operational Radar Bruce Neale GEC JoR No.3 Vol.2 1985
(Reprint)

(25) C.H.Transmitter Type T1940 (RAF)

The CH (Chain Home) was the first operational Radar System in UK, the first station being operating in the hands of the RAF 1937. It was the mainstay of the Defence of Britain during the whole of the War, although it was supplemented by other Radars to fulfil additional requirements, such as the CHL (CHain Low) in the form of a 150cm system. The CH operated in the band 10 to 12 metres (earlier ones in a wider band 10 to 15 metres), which filled in the lower elevations below the rather high lobe of the CH caused by the interference of the main and sea surface reflected waves.

This Air Publication only deals with the Transmitter, and DHT did not hold a corresponding Receiver or Aerials A.P. This particular volume was a reissue of the earlier wartime document, after a major refit of the CH system after the War, and various differences will be seen if comparing with descriptions of the wartime stations.

Contents:

25/1 Air Publication 2911 BA Vo1.1 Part 1 Chain Home Transmitter AM
Aug 1955 (Introduction, 7 chapters, 1 appendix)

(26) The Magnetron

Magnetrons of various kinds have been known and used as generators of short wavelength electromagnetic energy since around 1930. All these however only produced micro or milliwatts of energy, down to around 10 cms. They were however based on an experiment by Albert Hull in 1920-21. The definitive experiment did not produce energy, but demonstrated an interesting phenomenon. By that time, vacuum tubes of two types had been produced, the diode and the triode. The diode consisted of a heated filament and an isolated metal or conducting plate mounted at a distance from the filament. The shape of the plate used as an anode or electrically positive electrode varied according to the purpose for which required. However, a convenient shape was an open ended cylinder, with a central axial filament. These could be used to rectify alternating sources, the filament being the negative electrode and the anode the positive. Versions of these were used to 'detect' radio signals.

These uses were simply electrical circuits. Hull however introduced a magnetic element, by applying a uniform magnetic field also axially with the anode and cathode. By varying the field for a constant potential between filament and anode, he showed that at a certain field, current stopped flowing in the circuit. In fact the transition was not sudden, the current decreasing as the field increased, until current ceased. However the onset of decrease was well defined for each circuit condition. He called this the magnetron effect. He could not suggest any special application but hinted at the valve being used as a generator of RF energy, or as an amplifier.

He demonstrated the inverse effect, ie constant magnetic field and variable potential, showing the cut off of current. He produced equations relating the various variables. Two papers by Hull, both in 1921 (copies) are included.

Very little further was done until around 1932, when valves with the anode split into two coaxial segments were produced, and oscillatory circuits coupled to the 'split' anodes. Near the cut-off point, and just beyond cut off, the circuit oscillated and small amounts of power could be extracted. Nobody succeeded in producing more than about 1 watt of energy by this means. In 1938, the Varian brothers in the USA, devised a new type of tube where electron beams were focussed through a small hole in a plate which was formed into a do-nut 1 around the electron beam. The beam then traversed a second do-nut of exactly equal form and size. By making a wire connection between the two do-nuts, the circuit was made to oscillate and as much as 10 to 50 watts could be produced. Various people around the world were interested in this valve called a Klystron, but there appeared to be no means of accurately controlling the valve performance. At the outbreak of the 2nd World War, it was realised that very short wave transmitters of considerable power would be required if accurate Radar equipments were to be made. Birmingham University Physics Department was mobilised to hunt for a means of generating power. An Admiralty Scientist suggested to Randall & Boot of the Birmingham Physics labs that there might be a possibility of combining the properties of Klystron and magnetron. They however first went back to basic principles, and reconsidered the Hertz experiment of generating a spark attached to a tuned radio frequency circuit, when it was shown that a single coil of wire, with a small gap, picked up energy from the 'transmitter' and a spark occurred across the gap. They considered the circle of wire as a tuned element and the encircled area as analogous of the do-nuts. They therefore produced a cylindrical block of copper with a cylindrical central axial hole they then bored a series of accurate cylindrical holes around the central hole, using an even number of holes. With a filament down the central hole and a magnet producing a uniform axial field they demonstrated that very large amounts of power could be produced when the fields were such

that the current flowing in the valve was minimised by balancing voltage against magnetic field. There are accounts of this work produced after the war.

The work was totally secret during the War, and indeed only a few people actually worked on the development. Initially production models were produced by CEC at Wembley, mainly for the RAF for airborne radars and for the Navy. All these were of relatively low power, producing 10KW power, generated as 1 microsecond pulses. Calculation showed that the Army required not less than 100KW, 1 microsecond pulses and preferably 250KW. The British Houston Co. (BTH), at Rugby had been given the task of building the first centimetric Anti-Aircraft Gun laying radar, and they set about studying the GEC magnetron, and within 3 months (March 1941) had improved the power to 120KW and by late 1941 the first 250KW magnetron had been produced. The BTH engineers involved were Rushworth, King and Latham, and their definitive paper of April 1946 is included.

Later BTH development produced the first megawatt valve by 1945, and an improved design, generated by the Services Electronic Labs at Baldock, produced a 2.5MW valve in 1953.

Photographs of some of these high power valves are included, along with others of the early split anode valves of 1938 to 1945.

Detailed contents:

- | | | | | |
|------|--|-----------------------------|--|---------------|
| 26/1 | The effect of uniform magnetic fields on the motion of electrons between coaxial cylinders | A.W. Hull | <u>Phys Rev</u> 18 p.13 | May 1921 |
| 26/2 | The Magnetron | A.W. Hull | <u>J. American IEE</u> vol XL No 8 p.715 | Sept 1921 |
| 26/3 | The Cavity Magnetron | J. T. Randall | <u>J. Phys Soc</u> Vol 58 | Feb 1946 |
| | Transcript of an Address of Dec. 1945 | | | |
| 26/4 | An introduction to Multi-Resonator Magnetrons | Latham, King, & Rushworth | | |
| | | <u>The Engineer</u> | April 5 & 12 1946 | p.310 & p.331 |
| 26/5 | Microwave Magnetrons: A Brief History of Research & Development | | | |
| | W.E. Willshaw | <u>GEC J. Res.</u> Vol3 No2 | 1985 | |

Photographs:

- | | | | |
|--------|------------------------------------|---|--------------------|
| 26/6 | The first sealed off GEC magnetron | June 1940 | Type E1189 |
| 26/7-8 | 6903/84 and 6904/84 | A German 10cm split anode magnetron about 1944. The electronics are in the cylinder, and the tuning circuit is the Lecher wire transmission line with a terminating resistor at the end | |
| 26/9 | 6900/84 | British CV89 10cm low power multiple split anode magnetron about 1941 | |
| 26/10 | 6901/84 | Close up of multi anode of CV89 | |
| 26/11 | 6899/84 | CV79 British 10cm low power multiple split anode magnetron about 1941 | |
| 26/12 | 6905/84 | CV79, CV89, and German magnetron | Comparative sizes. |

- (27) Interview with Donald H. Tomlin
- 27/1 Transcript of an interview of D.H. Tomlin on July 24 2000 by Rosemary Preece, as part of an Open University project. 'Early days of Radar in Malvern'. Final version plus 3 drafts

(28) Lecture by Donald H. Tomlin

28/1 Text derived from a lecture by D.H.Tomlin at the Worcestershire Record Office One Day Conference, Nov. 18 2000, 'Second World War in Worcestershire.'

Lecture title : 'Impact of Radar on Worcestershire'. 2 copies

(29) Early Radar Proposals

- 29/1 Hulsmeyer Patent of 1904 'The Telemobiloscope'. A true 'State of the Art' proposal, using a spark transmitter and Coherer receiver. It is suggested that the equipment actually produced signals, although some commentators doubt the feasibility of the equipment to actually work.
- 29/2 Butement and Pollard 1931 Proposal for the detection of ships. Demonstrated to show signals from a transmitter to be reflected by a metal sheet and the range measured. Even so, not feasible at the time for distances of more than 100yards, due to low power. Very interesting proposal for range measurement, by amplitude modulation of transmitter by audio signal of varying pitch and detecting the frequency difference of the received signals. This does not involve Doppler frequency shift.

(30) The beginnings of British RADAR, November 1934 onwards.

Following the demonstration of Nazi Power in Germany, many people in high places were becoming alarmed at the prospect of a future War, and there was an increasing realisation that Air Power was likely to play a major role. In this country, Churchill was active, not being in any position of power, in drawing attention to the outdated Air Force and the lack of any defence against air attack. He knew all about Sound locators which were the only means of detecting incoming aircraft, and that these only gave a few minutes warning even against the low speed aircraft of that time. After the success of the British entry for the Schneider Cup Air Races and of the Air Speed Record being lifted to over 300 miles per hour, it was becoming obvious that several nations, including Germany, would be taking advantage of the techniques demonstrated, whilst Britain appeared to be just resting on her laurels. In fact higher speed aircraft were being designed even in UK, but with little Government support.

Wimperis, a Secretary to the Air Minister, wrote a Minute to his superiors, suggesting that Britain must do something, and suggested a Committee (What else?) to consider the problems from a scientific standpoint. His suggestion was immediately acclaimed, and various persons of scientific note were approached. It is most significant that no approach was made to the various technical institutes and engineering bodies. Wimperis was later said to have avoided these, because of the ease of leakage of information if representatives might be asked to account to their sponsors. It was already accepted that movement forward must be kept classified!.

Amongst the Members of the Committee, there was a scientifically trained engineer, by then a Secretary in the Air Ministry, A.P. Rowe, who was appointed Secretary to the Committee and the Chairman was H.T. Tizard F.R.S. He recognised that there were, coming in from the public and (non-scientific) bodies suggestions of using radio waves as a deterrent...as death rays as destructive radiations to burn up aircraft etc. He suggested that the question of using radio as a destructive force be put to the Director of the Board of Trade 'Radio Research Station' at Slough, Robert Watson Watt. In a very few days, the answer came back, that this was a non starter. Indeed, if all the radio stations of the world were to be harnessed into a single signal source, it would not produce sufficient power to destroy anything or to damage any human. This latter conclusion was almost certainly arrived at after Watson Watt had consulted another member of the Committee, Prof. A. V. Hill FRS, since the advice on this score is paralleled by a paper recording a discussion between Hill and Rowe.

However there was a sting in the final paragraph of Watson Watt's paper. 'It might be feasible to use radio to detect aircraft'. This was to bring the immediate response on behalf of the Committee, 'Please give more information'. Again within a short time WW provided a calculation of feasibility, and was then asked to demonstrate the possible means. It is again significant that WW knew that it was possible to detect aircraft. Indeed such detections were commonplace at Slough, where as part of the Service to the commercial and military world of radio, atmospheric radio soundings were made several times during the day, to determine the state of the Heavyside Layers for long distance communication. Frequently, the traces on the cathode ray tubes (which were photographed) showed reflections from aircraft leaving the Heston airfield some 10 miles away.

Contents:

- 30/1 Blue Folder: The early Memos suggesting and setting up the Committee, and the minutes of the first meeting
- 30/2 Sub file A. Watson Watt's paper on Destructive Radio Waves.

- 30/3 Sub file B. Watson Watt's paper on Detection by radio. (Based on calculations by Wilkins and Slow both of the RRS.
- 30/4 Sub file C Memo recording discussion with Hill.

(31) ADEE/ ADRDE/ RRDE in the War Years 1939-45.

The year 1985 was the 50th Anniversary of the first Demonstration which led to the development of Radar. Various celebrations were set up to mark the occasion, including a 3 day convention at the IEE in London.

More locally, in Malvern, D.H.T. wrote a series of articles for the local Press, 'The Malvern Gazette'. These were printed in 5 parts,

31/1 This file contains copies of the articles as printed but rearranged to fit A4 sheets. However because the articles had to be heavily pruned to fit the format being used by the Gazette, rather than the broadsheet for which they had been originally designed.

The opportunity of reissuing this folder has given the chance to include various correspondence following the original folder being circulated.

(32) 'Radar Development to 1945' IEE Seminar in 1985, the 50th anniversary of the decision to build a UK Radar Defence system.

32/1 Correspondence file between D.H.T. and organising parties.

Contains proposals for D.H.T. lecture, and for the proposed Exhibition during the period of the Seminar. Proposed programme of events and lectures.

(33) 'Searchlights to Radar'. The story of Anti-Aircraft and Coastal Defence Development

33/1 A 'popular' paper by D.H.T. intended for non-technical gatherings.

Describes the progression of development of means of defence from 1917 to 1953, after which UK Air Defence became the province of the RAF rather than the Army.

The progression of the Army Establishment from SLEE, through ADEE, ADRDE, RRDE to RRE.

Prepared in this form, as suitable for publication.

- (34) The Background to the GL3, the UK Army Centimetric Anti-Aircraft Radar AA No 3 Mk 2.
- 34/1 When the call for papers was made for the IEE Seminar on the Development of Radar 1935 to 1945, in 1985, the 50th anniversary of the decision to build a UK Radar Defence System, this is the paper originally offered by D.H.T. Whilst it was favourably received, there was a request later for it to be widened to include all UK Army Radars, and then just a fortnight before the event, a further request to include Army Radar worldwide. (D.H.T. was not amused, since amongst other factors, there was little time to prepare slides). D.H.T. obliged as far as possible, and the text of the final lecture is to be found elsewhere.

To keep the record, this paper has been included in the deposited files, even though there are no figures.

(35) RRE File Numbers for the 'Linesman' Project (including some for the allied 'Mediator' Project)

Within the Royal Radar Establishment Ground Radar Department, two of the three divisions (G1 and G2) were almost entirely devoted to the Development of the 'Linesman' Ground Defence System against Air Attack, from 1961 up to 1975, and parts of the divisions up to 1980 (the third division (G3) was concerned with Army Field Radar).

The Linesman system was closely allied with the Civil Air Control System, being designed and built at West Drayton, since by Treasury edict, both should share common radars and much of the associated electronic systems. It was also decreed by the Treasury, to save expense, that the RAF Central Defence Control system and the ATC UK Control system were to be co-located at one site (separate buildings) at West Drayton, where to the surprise of all, it proved absolutely impossible to house the Defence Centre underground, due to the site being effectively in a lake, filled with gravel, some 100 feet deep. The principal RAF Control Centre was therefore totally unhardened.

It didn't quite work out like that. The Air Force made it quite clear, that if any RAF radars were suffering jamming, that radar would be denied to ATC, and conversely, since ATC radars were not hardened against jamming, the Air Defence would not use them. Further, the selection of the many operational options for the various transmitters was vested solely in the RAF, without prior consultation, to meet apparent or real threats. Even so, both sets of radar signals were, at great expense, made available to the others, with necessary safeguards. Great expense, because the two sets of display equipment were incompatible, the RAF system being specially designed for its particular purpose, fully hardened against interference, whilst the ATC system was bought (from various suppliers) off the shelf without consideration of compatibility. When both systems were allied with computers to aid their specific tasks, these were utterly incompatible. The Linesman computer performed not only aided tracking and display management, but also did all the necessary computation for Fighter control, for multiple simultaneous interceptions and all access to it was denied to ATC on security grounds+. The Linesman system was basically proofed against failures in most parts, such that control could be maintained under most conditions.

+ ATC staff were not security cleared, being of international status.

The Linesman Radars included the Type 84, designed and built by Marconi Radar Ltd. at Chelmsford, with very direct control by RRE engineering staff, and Type 85 by Metropolitan Vickers at Trafford Park, and later after transfer, at AEI Leicester, and later Marconi Radar, still at Leicester. Associated with Type 85 was a Passive Detection system (PD) designed to give plots of jamming aircraft, without the need for ground transmitters, but using as one element, the Type 85 aerial system. This system, a joint brainchild of RRE and Marconi, Chelmsford, was built by Marconi, and depended on computer correlation of jamming signal envelopes, and when completed and for the first time put to multiple target testing, was shown to be totally flawed, since the number of plots possible did not equate to the number of targets, but to up to 'n' to the 'nth' as well as plotting reflections of any jammer by other nearby targets. The Type 85 itself was a very high power radar, basically designed to burn through the jamming signal and to give target returns greater than the jamming signals. Thus the two systems were complementary, the PD at longer ranges and Type 85 at shorter ranges. The Type 85 also had a computerised height finder built in, to give heights on all targets detected by the radar ... again completely overcome by any jamming.

The Type 84 radars were designed pre Linesman, but were incorporated because they had reasonably high powers, but principally because they operated in the 25 cm region of 'L'

band, whilst the 85 and other radars were all closely set in the 10 cm region. A degree of diversity was therefore available, and a comparable jammer was correspondingly larger and heavier, making it unlikely that both S and L jammers would be carried co-located. The set also carried the increased immunity to rain clutter, (Amplitude dependant on frequencies. See File 3). It included a MTI system with variable area, speed and direction control. (MTI = Moving Target Indicator, which permitted rain clutter elimination over wide limits.)

Beloved of Fighter Controllers, nodding height finders were included for direct access to heights by individual controllers on selected targets. This was satisfactory for a manual system, but proved not compatible with a computerised system. The Nodding sets were bought in from Plessey Radar (IOW) , but the decision was influenced by the RAF already owning some sets which had been intended for an overseas base, but cancelled. At considerable expense these were converted under RRE control, to be compatible with both the current (1965) site radar systems and later for the central control system from West Drayton.

The Linesman system in addition contained numerous types of (new concept) high speed digital data links (750 baud!!!) and wide band multiplexing systems for several radar pictures simultaneously being sent from local sites to the WD Centre. Altogether, from each of 4 military sites, 5 full data raw radar signals and 2 even wider bandwidth secondary radar signals were transmitted to WD. All these were accompanied by the necessary control and azimuth (real time) signals necessary for real time display control. All these signals were triplicated in each case within the multiplexing equipment in order to preserve availability in case of component failure in any part of the links. Triple comparators were used to determine which of three signals was different, and to drop it off line until repaired, without impairing the remainder.

All this meant of course at RRE, a vast paper control system, and a dedicated filing system, for full information sharing, and information retrieval.

This set of file indexes shows the extent of the system.

It should however be noted, that the Ministry of Defence archival system is controlled finally by non-technical staff, and decisions on historical value leaves much to be desired, and consequently, possibly only a very small proportion of the original files might survive. Equally, some files might be withheld from deposit at the National Archives at Kew, for different periods of time. However, those that do survive should ultimately appear in the 1 'AVIA' 1 series at the National Archives. However, there is always the possibility that similar papers or copies of the originals might appear in the 'Sigs 6' papers from MOD (Air) the responsible RAF Technical branch or from MOD (PE), the Branch controlling the production/development of any equipment. (MOD = Ministry of Defence. PE = Procurement Executive)

NOTE: ALL the Linesman system has been abandoned and dismantled apart from a lone Type 84 radar head, now part of the RAF Air Defence Museum at RAF Neatishead. (This Museum is open to the public, but the Type 84 is within the Radar Station Controlled area, but is available to view on selected days each year.)

All these subjects have been downgraded to Unclassified.

- (36) RRE File Numbers for all projects within the Ground Radar Department. Included will be at least part of the List for Linesman and Mediator (See File 35) but these might not be complete.

The coverage includes projects in all three sub divisions, G1 Display and Control, G2 Radar Heads and Air Traffic Control and G3 Field Army Radar.

The sequence in the Index is not Numerical, datal or alphabetical of the projects themselves, but are grouped in an alphabetical order based on types of project, i.e. under 'Displays', there could be a series of display systems, or even research items on displays. The sequence of types was derived by Mr. Ross, the Head of the Department in the 1960/70's, without regard to system considerations. Under these headings, there are several pure study areas including feasibility studies.

(37) RRE File List for 'Orange Yeoman' (RAF Radar Type 82).

The Radar Type 82 started as a new Radar for AA Command in the Army, for which studies began in 1945. There was a considerable period whilst these studies covered all aspects of Early Warning and Tactical Control. In 1947, the first study contracts were let to industry to follow up certain aspects of the RRDE studies, mainly to B.T.H. at Rugby, and then in 1948 B.T.H. was awarded another contract to design and build the next generation of tracking radars for AA gunnery, a technique for which B.T.H. were by then masters, following the AA No 3 Mk2 (GL3) and AA No 3 Mk 4 and 7 (the first totally self-tracking radars, in three dimensions), requiring high accuracy of gearbox design and manufacture. They therefore asked to be released from 'Orange Yeoman' to concentrate on techniques they were entirely familiar with. Metropolitan Vickers were selected to carry 'OY' forward, with a degree of collaboration from B.T.H. (Both companies were associated in Associated Engineering Industries (AEI)).

In 1953, AA Command was abolished and Air Defence of the UK became entirely RAF based. Guns were abandoned for AA, and (unproven at that time) Guided Weapons were introduced. It was deemed necessary at that time for the proposed Army Control system to be applicable to this new system, and 'OY' continued under new Requirement Authorities i.e. the RAF. Many changes to the proposed procedures were however introduced, and RRE was responsible for incorporating them.

RRE took the major role in forwarding the design of this new Control System, and built a complete (engineering) prototype at Malvern, whereby every circuit technique could be proven before MV 'engineered' that part of the equipment.

There was an embryo Development Model being built for the Army, at Frodsham, but after consideration, the RAF decided that a new prototype should be built on what was to be one of the operational G.W. stations at Northcoates. The Army prototype was completed, however, since it was near to MV Co (They were at Trafford Park, Manchester, and Frodsham is near Chester). It served also as an initial training ground for RAF Instructors, since many of the techniques were entirely new. The choice of Frodsham had been made for similar reasons to that of the RAF to use Northcoates, in that the Army prototype was to be the control Centre for the Liverpool/Manchester Defended Area for which an AA Operations Room already existed close by at Frodsham. This area concept was dropped by the RAF in favour of defending Attack Response Facilities such as Thor Rocket sites and Nuclear Air Bases.

The file system is therefore very extensive, and in due course, many of the important files should reach the National Archives (See File 34 information sheet for provisos).

Orange Yeoman was the only radar system which was designed as a complete entity. Most systems consisted of radar heads, display systems, control facilities and communication systems, all designed as separate items and then coupled together. Often new facilities to replace parts of systems were independently fitted together, and there were frequent mismatches of the various parts. From the very beginning, the OY was designed to make the system as efficient as possible, bearing in mind that low receiver performance could only be improved at great cost by increasing transmitter power, or increasing aerial size, reducing the beam width, which then impinged on visibility and discernibility of signals on the PPIs (Plan Position Indicators). Thus every suggestion for change was always scrutinised critically, to ensure that either they did not affect other parameters, or that appropriate action was taken in other areas. The 1946 RRDE studies related transmitter power, receiver noise factor, linearity, types of PPI Numbers of pulses per paint, aerial rotation speed, pulse repetition rate, maximum range required on a specified minimum size target (2 square metre reflecting

surface), aerial dimensions (beam width) as minimum characteristics. No other system has ever been matched in all these parameters so closely.

(38) 'Watching the Skies'. Initial Draft written by Jack Gough and Comments by DHT on the contents of the draft.

Following the Symposium held at the IEE in 1985, on the Wartime Radar Development up to 1945, the Historical Branch of the RAF determined to bring the history up to date as far as operational considerations permitted, at least up to 1985 and in some cases, later. The original editor was to be an RAF Officer, but he died before even the research had got under way: A second Officer was appointed, but he was not available immediately, and died before the work started. The third choice was Jack Gough.

Jack was originally a member of ADRDE at Christchurch, working on the 'Light Warning' set, a 150 cm radar, used by both RAF and Army as an easily transportable radar, of relatively low power and range. It was however very useful as an early warning set, operating out to about 20 miles. It was used in the Field as early warning and 'Putting on' for the GL3. In 1948 he became a part of the early 'Orange Yeoman' group, handling the contracts. In 1952, because of the interworking intended between the RAF and Army Control systems of AA Control Rooms and RAF Plotting and Control rooms, he studied the proposed RAF Post War redevelopment of these latter, and also the use of several RAF Radars, notably the Type 80. It had been intended by both RAF and Army to diversify radar frequencies, and the use of 25 cms as well as 10 cms was mooted, the advantage not only being the additional frequency band, but also the improvement of performance when rain was present. To this end in 1946/7/8, DHT along with Mr Merrifield had used the Giant Wurtzburg, brought to UK in 1946 for evaluation, to study aircraft reflection characteristics on 25 cms, using an army 25cm transmitter and receiver installed in place of the 50cm equipment. In due course, Jack became responsible for matters concerning the 'OY' transmitter, and after the death of Geof Beeching, the Group leader, he assumed control of the project, but was then transferred to the TRE site of the recently amalgamated TRE/RRDE (by then RRE) to start coordination of the requirements for a very high power 10cm radar, having sufficient power to provide reflected signals from invading aircraft, larger than the direct signals from the jamming aircraft. All this stemmed from the demonstration of a newly developed (and well publicised) French wide band, high power valve, the 'Carcinatron'. By 1962, this work was with contractors for development, and then Jack was suddenly moved to Min. of Defence 'Chief Scientist's office' in London, as one of their junior scientists. (He was by then a Deputy Chief Principal Scientific Officer, but admitted that in this London office he was the tea maker!)

He followed this with a spell in the MOD Procurement Executive and then reached retiring age. It was shortly after this that he was asked to take on the writing of the historical book on radar, wartime to 1985. On the face of it he was well able to do so, but had by then taken no part in the real development of the advanced Linesman system, and had had no direct connection with its predecessors, Rotor or the ill-fated Ahead programmes. Ahead was proposed as an all-singing all-dancing control system for Air Defence, using techniques which were only vague hopes for the future (e.g. data on all aircraft recognised by the radars were to be transmitted in digital form to control centres from radar stations where the data was to be extracted, processed and then sent to the centre. It required data transmission rates, (to avoid overload and delay) of some 20Kbaud, on multiple transmission channels or 150Kbaud if on simplex: channels, all at a time when 750 baud was the limit permitted on public networks). Even 20 years later, Linesman could not attain this.

He agreed to do the work, assuming that he could obtain most of the background information from past colleagues, only to find that this approach was barred, and he could only rely on official documentation, as the basis for his research and planning. He tried vainly to make an

acceptable story, but there were so many misconceptions, misunderstandings, and so many variations from fact, that it was inevitable that the draft would contain errors.

He passed typed copies of his draft to several people who were to comment. D.H.T. was but one, but collectively he was told him that it was unsound, and at a meeting with two of the 'objectors' representing all the others, and a representative from the Historical Branch, most of the objections were thrust aside as not being supported by 'Official papers'. Jack did however make some alterations, but the published book still had hundreds of errors.

NOTE: Official papers are, almost invariably, minutes of meetings and memos involving the higher ranks of MOD, and never contain the actual working documents from the working levels. Reporting to these bodies is always politically motivated, but seldom represents the true working conditions and facts.

Some of the Post War radar pioneers and designers of the 1960's, many from Marconi Co, and who had been directly involved in the 1960/70 developments, went so far as to try to get the IEE to intervene, but they were not inclined to gain adverse criticism from the MOD.

D.H.T.'s criticisms were never typed, but were passed to the above committee and fully ventilated. Hence what is in this file is the manuscript copy.

This first draft of the book is in 2 parts:

38/1 Part A (File 38a) Introduction and chapters 1 to 5.

38/2 Part B (File 38b) Chapters 6 to 9 and appendices

38/3 and (File 38c) contains D.H.T. comments

38/4 (File 38d) contains suggested photographs (photocopies of) to accompany the text, as requested of D.H.T. by J.G.

The book however serves a purpose in that most parts of the post war radar system are discussed, but details should be further researched before being quoted. A copy of the book is held in the Special Collections Department.

Jack Gough died in the late 1990s.

(39) Bawdsey RDF Manual Vol. 1, Parts 1 & 2

From 1936, an experimental model of the proposed Early Warning RDF system was built at Bawdsey Research Station, at the side of the River Ebden in Suffolk. This was to be followed later by a long chain of stations spaced between 10 and 30 miles apart right round England, Scotland and Wales, on or near the coast. The design was at the time an unknown factor. It evolved rapidly however, and by 1938 was sufficiently documented, to start a manufacturing programme in industry. However, right from the start, it had been recognised that the stations were costly and that even the experimental prototype at Bawdsey must be designed and built so that it could be manned and operated by RAF personnel as a fully operational station. It was also recognised that the only people who could train the operators were the designers. To this end, the personnel of the station were caused to write up a complete description of all parts of the equipment. (No doubt there was a large degree of editing and drawing together of the various contributions into a comprehensive whole, by a competent scribe, but DHT has found no information on this point)

The two documents here, Vol. 1 parts 1 & 2 came from a Squadron Leader Stewart, long after his retirement from the RAF, and indeed some 15 years after he retired from industry, where he had worked for Ferranti Ltd mainly installing their products, and for some years was involved in Orange Yeoman and Linesman, as such an installer. He had been stationed on many war-time and post war radar stations. (The term Radar replaced RDF in 1943)

These volumes (copies of) are Number 3, so must be early versions.

This technique of requiring the design personnel to write the handbooks was a very important point, in that it ensured that the equipment was truly understood, and that any particular circuit was not operating 'by chance' or 'fluke' ! It also built up a staff competent in writing reports and technical documents. This system was applied also to the attached War Office Staff, who were originally intended to observe and imbibe as much as possible from the Air Ministry researchers, and then go back to their own Establishment at Biggin Hill to apply the techniques to War Office requirements. In the event the staff became interchangeable and all stayed at Bawdsey until the outbreak of War, when the ADEE staff went to Christchurch. The system of the designers writing the technical handbooks continued at ADEE until 1943, when the pressures of original design work made it impossible to continue the practice. TRE after going to Malvern also set up a separate Publications Section, to produce not only draft Handbooks, but also Scientific Reports on their work.

39/1 Part 1 covers in chapters, The Evolution and principles of RDF, Application of RDF to 'Operations', The Cathode Ray Tube and its applications, Polarisation of Electromagnetic Waves.

Part 1, Chapters 2 and 5 had not been written at the time this document was issued.

39/2 Part 2. RDF Aerials, covers in chapters, RDF Aerial System, Aerials and Aerial arrays, Theory of Transmission Lines, The 'Inductive Radio Goniometer', Phase alignment of Aerial Systems, Matching of Aerial Transmission Lines, Height determination

Part 2, Chapters 8, 9 and 10 had not been written at the time this document was issued.

(40) Reports of Fighter Command Research Section

From the outset, RDF was always seen to be capable of improvement, and the first RAF Set, (RDF 1, also known as Chain Home 'CH'), was no exception. These two reports written by RAF Officers in the Scottish region cover suggestions for such improvements (often not implemented), as seen from the point of view of the local staff. These reports would then have been sent to the Research Branch and after as degree of vetting would have been issued.

40/1 & 2 The two reports were issued in September 1941 and in September 1942 respectively, under the auspices of '14 Group'.

(41) Unofficial Descriptive notes on RDFI, 'CH' or the later official title 'AMES* Type 1'

This is a simplified description of the first type of Radar to be produced for the RAF. For what purpose it was written or by whom, DHT had no idea, nor had his many friends. It was given to DHT by Sq.Ldr. (Ret) Stewart, somewhere about 1973.

41/1 It is in two parts, the first being a general description, and

41/2 the second a Technical Appendix, along with drawings.

From the footnote on Page 1 of the general description, it would appear to have been written around 1956, at which point there was a renewed interest in reviving the old original equipment, and trying to 'modernise' it to meet current purposes+. This in view of the scarcity of money to build new and 'state of the art' radars and systems. This was spurred on also by the new jamming threat on microwave bands (The Carcinatron): although it was generally acknowledged that the meter wave bands were vulnerable to simple jammers, there was however, a general belief amongst non-technical bodies, that it would be easy to master such jamming using up to date techniques (1953 et seq). The truth was in fact the opposite! This belief came about because the simple electronic jamming of 1940 against CH had been minimised by simple techniques. By 1955, jamming was far more sophisticated.

These notes could have been produced by some RAF personnel, as a means of reviving memories amongst some who had been away from the 'front line' of radar since the War.

Equally, it could have been written for local use by technical personnel, as an act of frustration, since technical manuals were at that time still generally classified 'Secret' even though they had long since been downgraded (officially). Such manuals were kept locked away by the Station Commanders. It was often for this reason that performance of stations was inferior, since it depended on staff memorising information, and the training schools gave scant attention to the older types of equipment.

*AMES =Air Ministry Experimental Station, the term used for almost all RAF Ground Radars from 1940 up to the 1990's. Often termed as AMES Type X, where X ranged from 1 (CH) to 85 (Blue Yeoman).

+ See File 42

(42) Comments on proposals to improve RDFI, (CH) (AMES Type 1), 1953 to 1956

Long after the end of the War, the CH System remained in operation, although by then almost 20 years old, with very little update having been carried out. From time to time, proposals for improvement came from interested technical and operational sources, but very few apart from minor aspects had been actioned. In 1953 to 1956, concerted attempts to update were made, to revive the old equipment. These papers are the response to these activities. Indeed at that time some improvements were made and several of the stations continued in use up to about 1962, but then most were closed down, as a new generation of radar sets and display systems came on line.

(43) Scrapbook assembled by Dr. D. R. Chick

Dr. D.R. Chick was a senior officer at the Air Defence Research and Development Establishment, having joined its predecessor, the Air Defence Experimental Establishment just before the war, and worked on the Army Radar projects with the War Office team attached to the Bawdsey Research Station, returning to ADEE at Christchurch on the outbreak of war. He worked on equipments operating on 150 cms, including the early Searchlight Control set, (SLC or 'Elsie') of which he was one of the original proposers and designers. He followed this with work on the Light Warning radar (LW) and then on a variety of 3 cm sets for coastal purposes, including the Shell Splash Sets, used for determining the errors between a ship target and the actual fall of shells by means of the Shell Splash or fountain of water as the shell burst.

In the late 1940s, he left the Radar Research and Development Establishment, RRDE, as it was by then, and joined AEI at Aldermaston, a private company exploiting the nuclear energy offshoot of irradiation of materials, to produce isotopes which could be used in industry and in medical fields. He became the Research Manager at Vickers Research Centre at Ascot in 1963. From there he went as the Professor of Electronic and Electrical Engineering at the University of Surrey in 1966. He died in 1978. (See the File of Obituaries)

This Scrapbook was given to DHT by his Widow, to ensure it was not destroyed. As its name implies, it is a very general collection of newspaper and other articles on a wide range of subjects, some given to him by others, since 'He might be interested'. They range from Radar topics, via the unfolding of the Radar Story immediately after the War, nuclear matters, industry and education to philosophical notes.

Much of the matter has appeared elsewhere, but it is at least brought together in one place, and shows the wide ranging interests of a Scientist and Engineer, and as such is representative of so many of the Radar Scientists of the War years and after.

(44) DHT contribution to the 'Convocation Archive'

The Convocation Archive was first announced in the year 2000, and contributions were requested from anybody with connections with the University of Sheffield , whether as student, academic staff, general staff, or in any other manner, at any time. It was hoped to get a cross section of the 'inhabitants' over a wide span of years and interest. The intention was that the Editor of the new University History for the Centenary of the Inauguration of the University could draw on anecdotes, comments on curricula, teaching and any other matter pertaining to the University and Halls, to illustrate the book.

This was DHT's rather lengthy response. DHT felt that it was impossible to consider the three years direct connection with the University, without considering the social and political aspects of the times before and after, particularly since his third year was also the first year of the War. It is included in this Radar Archive, because of the impact of his previous experience and University matters on his subsequent lifelong career in Radar.

It has been put in this Radar Archive with the permission of the Editor of the Centenary History and the prime mover in Convocation instituting the 'Convocation Archive'.

(45) Proceedings of the IEEE (USA) 1985 International Radar Conference

In 1985, there were two major Conferences on Radar, the prime one being at the IEE, sponsored by the Historic Group of the IEE (S7), the Proceedings of which are published in the book 'Radar Development to 1945' edited by Prof. Russel Burns and published by the IEE, and the second one by the IEEE of the USA. This pamphlet containing copies of the papers from the IEEE conference was circulated to the Presenters of Papers to the IEE Conference and other interested parties.

It contains copies of papers mainly by USA Engineers and Scientists, but one by A.E. Bailey gives details of his pioneering work on Pulse Doppler and other techniques at the Air Defence Research and Development Establishment 1943 to 1945

The Pamphlet however also contains a very comprehensive 'Cumulative Index of papers on Radar' (Second Edition).

(46) Radar: Index of Equipments

The most comprehensive Index to Radar Equipments worldwide, compiled in the 1945 to 1960 period, is contained in a USA set of books not generally available, but there have been some copies in UK in selected Service and Design Establishment Libraries.

RRE/RSRE/DERA had such a copy, but this has been either destroyed or sent to an unknown destination. It might one day come to light.

The second best, is that included here. Originally drawn up as a training document by the Royal Artillery, at the School of Anti-Aircraft Artillery, it covers most of the UK Service radars up to about 1950, with some mentions of projected radars of later date. The American, German and Japanese entries are mainly limited to war time equipments. Unfortunately, there are only a few representative sketches of equipments, whereas the American books have small photographs of almost all the basic equipments, but not necessarily variants. This document does however contain details of the basic parameters of most of the sets, but not necessarily of all types derived from the basic type (there were very large numbers of derived types, made or modified for very specific applications). DHT has added a note in an attached sheet, extending the data on the RAF Type 84 set.

(47) DHT Physics Lab Work Book, 1939/40.

Most of the experiments described herein are routine measurements within the general course.

However DHT had read the paper in Phys Rev of the experiments of Hull in 1921, and also, through his interest in short wave radio, had heard of split anode magnetron oscillators, although had never met one. He consulted Dr. Conn, one of the fairly new lecturers, and he suggested that, if DHT could find a cylindrical anode diode with a central filament, it might be possible to reproduce the experiment. DHT found a Cossor diode (in a 3" diameter glass bulb) and decided to try it. That the surrounding magnetic field did cause a diminution of the anode current, with a series of characteristic curves dependant on the anode voltage at constant field or vice versa, of current with constant voltage with varying field. There was no sudden change as found by Hull. However, by using the point where current started to diminish, it was possible to obtain a near approximation to the value of e/m .

Subsequent measurements made with a vernier telescope, it became apparent that the filament was not concentric with the anode, and therefore the cut off at points along the filament could be expected to be spread over a wide field/voltage variation.

This particular experiment was of use subsequently, when the Radar GL3 (AA No 3 Mk 2) anti-aircraft radar started to go into army use. This set used an electro magnet to derive the magnetic field coaxial with the anode cylinder, and the exact value of this field was specified for each valve for optimum power output, within the limits of the factory test specification. This was all determined during factory test. However, in attempts to improve the performance further, Corporal Bloom and DHT found that by varying the field it was possible to find points of greater stability of the valve, and in many valves, much higher powers*. It was necessary to have an easy means of measuring the magnetic field at these enhanced points, so that they could be replicated. However, there was only one 'Gaussmeter' available at RRDE, and they were very expensive. DHT, remembering the experiment, used a Mullard diode (EA50) which had a cathode rather than a filament. These valves also had electrode connections in the form of pins at each end of the cylinder (unfortunately made of iron and which caused slight deformation of the magnetic field). The valve just fitted between the polepieces of the driving magnet. Using the one Gaussmeter, the team closely calibrated the field current to the magnet, and then found that by placing the diode between the magnet poles, having removed the 10 cm magnetron, it was possible to calibrate the diode against its anode voltage thus providing a characteristic curve rather than finding the first current change point. Around 500 of these bits of test gear were provided for the technicians in charge of maintenance, and it was possible to improve the performance of the radars in the field. The cost of these small pieces of test gear was a small fraction of the cost of Gaussmeters and were made available in weeks rather than years.

* The CV120 magnetron had a nominal power output of around 250KW (with 1 microsecond 400pps recurrence pulses) but the team obtained in selected valves up to 400KW with good stability).

(48) (EKW)

This is a collection of files passed to DHT by the widow of E.K. Williams, to safeguard them from destruction. They are the collected papers of Eric K. Williams, known throughout TRE simply 'EK' or 'EKW'. He was a Senior Scientist at TRE (Telecommunications Research Establishment), and later RRE (Radar Research Establishment).

E.K. Williams B.Sc. MIEE, ISO.

Eric Kenneth Williams was born on 24 April 1917, and spent his early life in Chelsea, and then, having gained a scholarship, went to Westminster City School and then to King's College, London where he gained a First Class Honours Degree in Physics. He went on to start a Ph.D. Course, but this was interrupted in June 1940 on his being directed, as a scientist, to 'War Work' at the Air Ministry Research Establishment (AMRE), later to become the Telecommunications Research Establishment (TRE) at Worth Matravers, Swanage. Here he was allocated to the Airborne division, i.e. to work on Radar or similar equipment to be fitted in aircraft. He recounted that this appeared to be because he 'had an interest in aircraft' having once taken a 5/- trip in an aircraft! He was to stay in that Division for 40 years.

In 1942, TRE moved from Swanage to Malvern where they were located in the Boys College, the Boys having been evacuated. EK was much involved in the sporting and literary activities at TRE, and after the war, in trying to integrate the Establishment and town, when it became known that TRE and its sister Establishment RRDE (Radar Research & Development Establishment) were to stay in Malvern. At that time he was the Editor of TRE's House Journal 'Echo', and he cooperated with Joyce King, the Editor of the Malvern Gazette, to foster such cooperation.

Early in his career, Eric became involved in welfare issues, and worked for the Institute of Professional Civil Servants, and was chairman of the Staff Side Whitley Committee for 25 years, during many changes of both name and structure of the Establishment. In 1952, TRE and RRDE joined to form the Radar Research Establishment, later to receive the Royal Accolade and become the Royal Radar Establishment 'RRE'.

His initial work at Swanage was on the 'RDF Range Finder', and his last was on 'Blue Fox', used in the Falklands war. On the way, he worked on many of the branches of electronic warfare in its broadest sense jamming, spoofing and beacons especially Rebecca/Eureka, which was used to assist accurate location of dropping points for agents behind the enemy lines, for dropping troops in the invasion, supplies of all types and food to the Dutch (as well as for allied troops). This was to be used in various forms long after the War.

From around 1950 he was attached (along with his Divisional Duties) to the Central Division of TRE and remained as such with RRE, making use there of his literary abilities. He was the Editor of the 'TRE Journal', in many ways equivalent to a Journal of a Learned Society. It however dealt with research within the Establishment which required disseminating amongst other members of staff and outside bodies entitled to have the information, but which was unsuitable for general publication on the grounds of security or 'need to know'. He edited individual scientific papers and reports, some of which were again of restricted circulation, and some which were destined to be published in scientific publications.

He was however called upon to study specific problems and to publish internal reports on them, sometimes as a preliminary to contractual action for further study and/or research and development in industry. Some of these reports were condensations of a topic, in order to give higher echelons in the Establishment background information on the topic, often as a preliminary to attendance at meetings or major conferences. These papers cover a very wide

range of radar and allied subjects, and EK became a real font of knowledge and was much sought after. He collected many papers from other sources and especially from industry. Several were critical appraisals.

One special editorial task given to him was to produce a house journal for the combined Establishment RRE, and this, 'Focus', was a social journal, carrying also histories of the Establishments, in order to bind the staffs closer together, but not scientific papers.

Unfortunately, it was produced against the climate of Governmental cost cuts, and after some three years, the cost could no longer be justified, and it fell by the wayside.

In 1950, Eric married Betty, who as a nurse had tended him after he was injured in a sporting accident, and there were two daughters. In 1972, his work was rewarded by the receipt of the Imperial Service Order medal for Service to his Country. He was a Member of the Institution of Electrical Engineers. He retired in 1978, and worked for several years as a consultant to both RRE and industry. He died on 24 January 1997.

A notable scientist, a model editor, but above all, a family man, and it was his wife and daughters of whom he was most proud, as they were of him.

The Files are listed in the main index, indicating the main interests of the contents of each file, and each file contains a detailed index of the papers contained, but not with any detailed comment on the content of individual papers. The Files are listed as part of the main Radar Archive, but are distinguished as below:

‘Contents of File 48 (EKW (1 to n)), followed by the title.’

The papers have been collected together in suitable groupings so that they could be listed under generic titles.

DHT is indebted to Mrs. Betty Williams for the honour of her allowing him to place these valuable papers in the Radar Archive at Sheffield University Library, where they will be available to researchers and interested parties.

In addition to these papers of scientific and historical interest in Radar, there were a small number of papers and pamphlets which deal with RAF Radar Equipments and which are specifically of technical interest. These were placed at the RAF Defence Radar and Control Museum at RAF Neatishead (Norfolk), where they will be equally accessible, but of most interest to members of the RAF who have been or are Technical or Defence Control Staff. A list of these papers will be added as a File in the Radar Archive, and cross indexed with the Museum data.

(48) (EKW 1) Radomes, Aerials, Phased Arrays, Scanning

Contents:

- 48/1/a Aerials and Radomes, Airborne requirements. Paper to 'Radar 74' Conference
- 48/1/b Inertialess scanning, by Frequency Scanning alone. Paper by J. Croney
- 48/1/c Personal calculations concerning launching modes
- 48/1/d Personal calculations relating to corner reflectors
- 48/1/e Radar Design implementation: Antenna Systems
- 48/1/f Electronically scanned antenna. Radar 74/75 Conference
- 48/1/g Radar Design and evaluation by modelling. RRE paper
- 48/1/h Cassegrainian aerial (Elliott Marconi)
- 48/1/i Handwritten information on aerial cables and attenuation
- 48/1/j Graph showing relation between dimensions of aerial and beamwidth at various frequencies

(48) (EKW2) 'Chirp' and 'SAW' Devices

The term 'Chirp' Radar is generally meant to imply a radar whose transmitter modulation is in the form of a long (narrow bandwidth) pulse, but which pulse is frequency modulated either in steps, or continuously, linearly or randomly or according to a plan.

Chirp radars were introduced originally to spread the frequency of a radar, as a means of combatting noise jamming, using narrow band filters covering the bandwidth of the spread frequency transmission, but have been used as a means of moving the beam centre of a transmission, as an anti-jamming means or for instance height finding, or to give wide or narrow scanning in space.

48/2/a Reprint from Bell Tech J. July 1960: The Theory and Design of Chirp Radars.
Klauder, Price, Darlington and Albersheim

48/2/b Signal Processing aspects of Non Linear Chirp Radar Signal waveforms for Surface Acoustic Wave Compression Filters. Newton of RRE Malvern

48/2/c As (b) above, but reprint of published version in Wave Electronics 1974/76

48/2/d Surface Wave Acoustic Devices for Signal Processing.
Mains & Paige, Proc IEEE 1976

48/2/e A Tapped Delay Line Active Correlator: A neglected device.
Darby & Maines, RRE, Malvern

48/2/f A Surface Acoustic Wave Dispersive Filter with variable linear frequency/time slope.
Newton & Paige, RRE, Malvern.

48/2/g SAW. RSRE Malvern. A List of SAW Manufacturers & manipulators. 1977

48/2/h Photocopy from IEEE' Ultrasonics Symposium (1978). A Technique for realising low time sidelobes in small compression ratio CHIRP Waveforms.
Judd (Hughes Aircraft)

48/2/I Surface Acoustic Wave Components in Electronic Warfare Systems.
Gandolfo, Grasse & O'Clock.

(48) (EKW 3) Rebecca, Eureka and Monica.

These were code names for special Beacon Systems, intended to assist in the dropping of Agents or supplies to Agents behind Enemy lines, or to assist in invasion tactics and supply of advanced units. Monica was a Bomber Warning system against attack.

48/3/a TRE Memorandum D1/M4/JRM. 1948. Theoretical investigation of performance of Interrogator/Responder Systems.
Mills

48/3/b TRE Memo D2/M24/EKW. Report on Rebecca in Flight Trials.
E.K. Williams 1946

48/3/c Warning set for Bombers (Monica).
E.K. Williams. May 1942

48/3/d Map (TRE) showing Rebecca Eureka operations by 38 Group, July 1 to August 31 1944, in Europe

48/3/e Manual of Instruction for Rebecca (AN Apr2).
TRE, March 1944

48/3/f Radar Beacon Assault and Supply Operations 1942 to 1945. A map of Europe and N. Africa, pinpointing the various actions and their dates.

48/3/g The original Eureka Mk 1 used in Norway. There are two versions of this document, the first (two sheets) with several ink corrections, and the second, a straight typed copy (single sheet). (Probably used as description of exhibition unit)

48/3/h Report on Rebecca Trials. Paper by Sq. Ldr. P.B.N. Davis. The trials reported on took place Dec 17 1942 to Jan 17 1943. Attached is an operators training 'manual'

48/3/i Memorandum on the errors in use of Rebecca- Eureka.
No Author named. March 1945

48/3/j Rebecca Mk 3. TRE Report 33/R105/EKW. October 1942. A simple description, with Circuit Diagrams, by E.K. Williams

48/3/k Report on use of Rebecca in 'Husky' operations. A detailed report on use in the assaults on Sicily, Syracuse and Augusta. No Author or date quoted.

48/3/l Memorandum on Eureka IIIA TR 3514. Tested by TRE July 1943
S.D. Abercrombie

48/3/m Report on Radar Performance in 38 & 46 Groups in Operation 'Market', using Rebecca/Eureka.
W/Commandr. I.H. Cole, Jan 1945

48/3/n Preliminary Description of Rebecca 'H' system. March 1943

48/3/o Tech. Mem. on Rebecca/Eureka Mk.1b. prototype equipment from Contract 24711/C.31.b.
September 1942. R. Hanbury Brown

48/3/p Rebecca 4. Brief Resume on Investigation into serviceability . Handwritten Notes of a meeting by Squ. Ldr. P.J. Dunlop 8 August 1952.

(48) (EKW4) Radar 'Clutter'

'Clutter' infers radar signals from objects other than the required type. Hills, buildings, poles, towers and many other items including rain and clouds produce signals which can confuse or mask the required signals. Waves and Sea Clutter are covered in a separate file. (See 'Sea Clutter' File 48 (EKW12))

48/4/a Radar Clutter. An Elliott Bros Paper prepared by P. Kitson, Sept 1966

48/4/b Terrain Reflectivity. Handwritten paper by unknown author

48/4/c (Effect of) Polarisation of Radar signals for aircraft, precipitation and terrain.
Gent, Hunter and Robinson. Proc IEE, 1963. Measurements made 1950-53

48/4/d 'Scatterometer' Program.
Floyd & Lund. IEEE, 1994

48/4/e Backscatter from Terrain Targets at small incidence angles. Typed copy of talk at a 'Group Review'. Author and date not known

48/4/f Reflection properties of horizontal cables. Author and date not known. (TRE Group Tech Note)

48/4/g Radar Reflection Coefficient Data for X Band. Author and date not known. (TRE Group Tech Note.)

48/4/h Backscatter from Snow and Ice surfaces at near incident angles.
Hoekstra & Spanogle. IEEE, 1972

48/4/i Electromagnetic Reflection Properties of Natural Surfaces with Applications to Design of Radars and other Sensors. Extracts from paper by Cosgriff, Peake and Taylor. USA CRB 1064

48/4/j Echoing area of Mig 21 at 3cm. Handwritten note by 'DN' (?) passed to E.K. Williams. 4/6/1979

48/4/k NRL Terrain Clutter Study Plan 4. Extract from Lab report. Passed to E.K. Williams.

(48) (EKW5) Miscellaneous papers on Radar Scanners & Associated Topics

- 48/5/a Electronic Beam Scanning. E.K. Williams, Sept 1984. An in-depth appraisal of Electronic Beam scanning economics against other conventional and new scanning techniques
- 48/5/b Soviet Electronic Environment. E.K. Williams, August 1981. Considers the possible Soviet Tactical Theory of Radar Jamming and Countermeasures, and possible dispositions
- 48/5/c Electronic Jammer Scenario. E.K. Williams, May 1982. Follow on from (b) above. Considers the various findings and disagreements and uncertainties in parallel studies of Soviet Jammer Policy,
- 48/5/d Helicopter vulnerability, particularly in the 'pop-up' role. E.K. Williams, Feb 1983
- 48/5/e Over the Horizon Radar Scenario. E.K. Williams, March 1979. A General Consideration of the problem, particularly as applied to Surface Craft. Limitations of various schemes are spelt out.
- 48/5/f Light-weight Aircraft Radar Sensors Technology trends. E.K. Williams, March 1980. Considerations of various types of Sensor for use in light aircraft and Helicopters.
- 48/5/g Radar Antenna Gimbal 'Cross-connections'. E.K. Williams, April 1983. Considers the problems connected with aerial mountings which require multiple gimbal joints to carry out their scanning or similar functions. A simple example is the radar aerial with azimuth and elevation movements, which are also required to stabilise against roll and pitch.
- 48/5/h Results from an Experimental Dual Band Search Radar. P.D.L. Williams. Radio & Electronic Engineer, Nov/Dec 1981 (Reprint)

(48) (EKW6) Multi-Static Radars

Multi-static radars are those where transmitter and receiver(s) are separated in varying degrees. The Germans employed such a system in WWII, where they received target signals from Allied aircraft using transmissions from UK based transmitters, thereby attaining affectively 'Over the Horizon' target detection.

48/6/a An Analysis of Bistatic Radar. Skolnik. IRE Trans Aerosp. & Navig. Electronics, March 1961. A General approach to the theory behind Bistatic operation.

48/6/b IEE Colloquium on 'Ground and Airborne multistatic Radar', 4 Dec 1981. Synopsis of papers to be read

48/6/c Ferranti proposal in support of a contract bid. Proposal for Synchronisation Studies in support of an Airborne Research Programme, May 1983

48/6/d Are Bistatic Radars Worth Development? E.K. Williams, March 1945. The advantages and disadvantages of monostatic and bistatic radars and the economics.

48/6/e Handwritten Draft of (d) above, by E.K. Williams. Scope appears to be much wider

(48) (EKW7) IEE Symposium Millimetre radars

Notes by E.K. Williams on IEE Symposium on Milli-metre Radar Sensors. April 22 1980

(48) (EKW8) Anti Air Collision Devices

Copy of Paper 'Devices for the Avoidance of Collisions in the Air'. S. Ratcliffe, Electronics and Power, July 1985

(48) (EKW9) The Role of TRE in the Invasion

The Work of TRE in the Invasion of Europe. JWSP (Pringle). Undated, but inferred from Ch. 10 to have been around November 1944

Strokes are position markers along a time base, usually of variable position. In Radar Displays, they are used to pre-select positions along a time base, or as variables, to mark the position of targets in time from the radar transmitter. In many equipments, strokes are moved along the time base by mechanical means, usually a handwheel, to which is connected a variable element, capacitor or resistor. In Automatic strokes, the position of the target echo is sensed by electronic circuits, and the position automatically updated.

The position in time along the time base is usually indicated by a small portion of the trace being brightened compared with the rest of the trace, but in some equipments it is shown by a short step upwards or downwards, or even a step function, whereby at the selected position, the time base steps bodily to a new position and stays there for the remainder of the trace. Automatic strokes were very important in aircraft displays, where undue mechanical items have to be avoided due to weight. They also are used in automatically tracking radars, such as gunlaying radars.

Automatic Strokes and Recurrence-frequency selectors.

F.C. Williams, F.J.U. Ritson & T. Kilburn. One of the papers read at the IEE Radar Symposium 1946 (Reprint)

(48) (EKW 11) Aspects of Electronic Warfare and ECCM

Electronic Warfare has many faces. The simple part is just to put out an interfering signal on the frequency of the radar to be jammed. This however has to be effective, and so modulations of both amplitude and frequency are employed singly or together. It has to be of sufficient power, always remembering the radar signals are two way, and consequently of very low amplitude which varies as the fourth power of distance, whilst the jammer is a one way device, and its signal as received varies only as the square of the distance.

The more sophisticated jammer is INTENDED to be seen on the opposing radar screens, such as multiple aircraft echoes where either only one or even no aircraft is actually involved. There are many variants of this theme. (In the invasion of France, a spoof armada was shown crossing the Channel near Dover, to distract from the real one off Normandy. Similar spoofs were used in the Mediterranean area).

These various forms of 'Interference' have to be removed if possible and Countermeasures devised to either eliminate the interfering signals or to minimise them (ECCM).

- 48/11/a Aspects of Electronic Warfare. Anderson. Paper on Electronics and Power, May 1986
- 48/11/b Electronic Counter counter measures. A Ferranti paper. Dec 1982, but written by E.K. Williams. An overview of the many means within the receiving radar, to minimise interfering signals (as well as measures in the radar transmitter to defeat the antijamming measures!)
- 48/11/c Radar Noise Jamming calculations simplified. Kefalas. Correspondence in IEEE Trans Aerosp. & Electronics Systems, March 1981
- 48/11/d Radar Performance Review in clear and Jamming Environments. DiFranco & Kaiteris. IEEE Trans Aerosp. & Electr.Syst. Sept 1981
- 48/11/e Microwave Variable Time Delay. Hurley. June 1973 in 'EW'. A Technique used in many spheres of Radar but very useful in ECM and Spoofing.

(48) (EKW12) Sea Clutter

Sea Clutter is a special case of normal ground clutter, in that sea waves tend to have constant 'wavelengths' dependant on wind speed and direction. They also cover the whole of the visible surface, extending often to the horizon.

- 48/12/a Detection of Sea Ice by Radar. A Ferranti paper, written however by E.K. Williams, Jan 1982
- 48/12/b The Sea Surface .. Target or Clutter. IEE Colloquium Feb .1979. Synopsis of papers.
- 48/12/c Notes on (b) above. Handwritten notes by E.K. Williams.
- 48/12/d Constant False Alarm rate Detector for Pulse Radar in Maritime environment. Cole and Pin-wei Chen. Copy of Article IEEE 1978
- 48/12/e Non Coherent Model for Microwave Emission and Backscattering from Sea Waves. Wu & Fung Copy of Article J .GeoPhysical Research, Oct 1972
- 48/12/f Spectrum of Sea Clutter Echoes. Reilly. Part of a larger section in 'Radar Design Principles'
- 48/12/g Application of Remote Sensing by conventional Radars. P.D.L. Williams (Decca). Use of small radars for sensing air/sea interactions.
- 48/12/h Radar Clutter in Airborne Maritime Reconnaissance Systems. Ward and Watts. 1984. Modelling of Sea Clutter Envelopes
- 48/12/i Detection of Sea Ice by radar. P.D.L. Williams. IEE Conference Publication 105, 1973
- 48/12/j Radar Detection Probability with Logarithmic Detectors. Green. IRE Trans. Informn. Theory, March 1958. Following Research by the Admiralty Signals Establishment 1950 period, Logarithmic detectors were used to reduce Sea Clutter Returns
- 48/12/k Radar. Philip Williams, Decca Yachting World, Nov 1978. Vulnerability of small Yachts in Sea environment
- 48/12/l A Radar Sea Clutter Model and use in Performance Assessment. Ward. RSRE paper, 1982
- 48/12/m Nomogram from Asteraki, RAE, Jan 1969, to determine Wave Height as a common measure of sea state
- 48/12/n Sea Clutter. Longstaff, RRE, Feb 1975. Theoretical Models ... The Composite Surface Model for Long Pulses.
- 48/12/o Comments to RNAS Culrose re Sea King Simulator. Modelling of Sea Clutter in a simulator. Radar Performance Computer programme.
- 48/12/p Limitations of Radar Techniques for Detection of small Surface Targets in clutter. P.D.L. Williams, Decca. Paper based on Aerospace, Maritime & Military Systems Group, Dec 1973
- 48/12/q Radar Reflections from the Sea (Draft). No date or author. Results of a working party set up at RRE in 1972

48/12/r	Change of the Fading Characteristics of reputed steady targets as a function of Sea States in Marine Environment. P.D.L. Williams. <u>Electronic Letters</u> , Dec 1970
48/12/s	Sea Clutter dependency on Windspeed. Sittup. Physics Lab Technical Note, The Hague. Undated
48/12/t	Clutter on Radar Displays. Croney. ASRE. <u>Wireless Engineer</u> , April 1956. Reduction by using Logarithmic Receivers
48/12/u	Improved Radar Visibility of small targets in Sea Clutter. Croney. ASWE. <u>Radio & Electronic Engineer</u> , 1966. Paper presented to Radar & Navigational Group, London, Jan 1966
48/12/v	Dependence of Sea Clutter Decorrelation Improvements on Wave Height. Croney & Woroncow. No date
48/12/w	Pictorial and tabular Indications of state of the Sea. Effect of Wind and Waves.
48/12/x	Further results on detection of targets in non gaussian sea clutter. Trunk, US Naval Lab, Washington. Letter in <u>IEEE Trans. Aerosp. & Electr. Systems</u> , May 1971
48/12/y	Adaptive Radar Detection with Asymptotically Regulated FAR. Tugnait & Prasad. Letter in <u>IEEE Tr. Aerosp. & Electr. Systems</u> , July 1977
48/12/z	Harbour Surveillance Radar Detection Performance. Schleher. <u>IEEE. J. Oceanic Engineering</u> , Oct 1977
48/12/aa	Doppler processor rejection of Range ambiguous clutter. Ward. <u>IEEE Tr. Aerosp. & Electr. Systems</u> , July 1975
48/12/ab	Quantitative Analysis of Sea Clutter Correlation with Frequency Agility. Ward Beasley. <u>IEEE Trans. Aerosp. & Electr. Syst.</u> , May 1968
48/12/ac	Averaging Logarithms for Detection & Estimation. Ricker & J.R.Williams. <u>IEEE Tr. on Informn. Theory</u> , May 1974
48/12/ad	The Impact of new display technology on radar detection of small targets at sea. P.D.L. Williams, Decca. <u>Electr. Circ. & Syst.</u> , Nov 1979
48/12/ae	Further observations on Detection of Small Targets in Sea Clutter. Croney, Woroncow, Gladman. <u>Radio & Electr. Eng.</u> , March 1975
48/12/af	Logarithmic I. F. amplifiers
48/12/ag	Detection performance of the cell averaging LOG/CFAR receiver

(48) (EKW 13) Radar Reflectors for Navigation

Reflectors of various types were used initially to provide large amplitude signal returns in lieu of flying aircraft, for the testing and calibration of radar equipments during the WWII.

Initially, for the 5 metre radars and then the 150 cm radars, three half wave dipoles, joined at the centre of each and spread out to be mutually orthogonal. To these were added Corner reflectors, 3 sheets of metal or metallised paper, mounted so that the three planes were mutually at right angles. Generally these were made from a square sheet, with four right angled isosceles triangular plates, set so that the four right angles were at the centre of the square, all the triangles being on the one side. These were frequently flown away from the radar, on meteorological balloons, and as such were also used to determine wind speeds. For accurate measurements of performance of radars, spheres were used.

When Spoof towns and cities were built on open ground, corner reflectors, pointing upwards, were used to simulate buildings to give realistic radar reflections. Thus rows of reflectors simulated buildings along streets.

On the maritime front, small reflectors were attached to the top of buoys, to harbour and pier ends, and small ships also adopted reflectors to enhance their signals for safety reasons.

These papers give body to these schemes.

- 48/13/a The passive enhancement of Navigation Buoys at sea. P.D.L. Williams, Cramp and Bellion. Copy of Paper from Radar 77
- 48/13/b Targets for Microwave Radar Navigation. Robertson. Bell System Technical Journal. Date unknown
- 48/13/c Using Radar Reflectors. Feature Article. Yachting Monthly, Sept. 1976

- (48) (EKW14) IEE Proceedings F: Telecommunications/ Radar/ Signal Processing.
- 48/14/a Vol.127 Pt. F No. 2 April 1980 Special Issue 'Advanced Signal Processing'
- 48/14/b Vol.128 Pt. F No. 3 June 1981 (General issue), contains articles on Jamming rejection, Ground and Weather Clutter
- 48/14/c Vol.128 Pt. F No. 5 Oct. 1981 (General issue), contains articles on Sequential radar Detection of Border Penetration, Signal Processing in Phased Array Radar, Target Detection in FMCW Radar
- 48/14/d Vol.130. Pt. F No. 1 Feb. 1983 Special Issue. Adaptive Arrays
- 48/14/e Vol.130. Pt. F No. 3 April 1983 Special Issue. Spectral Analysis.
- 48/14/f Vol.130. Pt. F No. 7 Dec. 1983 Special Issue. Radiowave Propagation.

(48) (EKW 15) Lecture Notes

TRE like RRDE from time organised training lectures, given by Senior Staff, on Mathematics and other subjects relevant to new or junior staff. These papers pertain to Mathematics, given by Woodward, the Head of TRE Maths Dept.

48/15/a Statistics Data Sheet, and Graphs. No doubt the handout at one of the lectures. Probably c.1943

48/15/b Probability. 2 sets of Lecture Notes by Woodward (Hd. of Maths TRE). Also EKW Personal Notes

(48) (EKW16) Bombing Accuracy.

- 48/16/a Relative importance of Frequencies of Radar systems on Fixing & Bombing Accuracy of Buccaneer 2 Aircraft. E.K. Williams, Sept 1963
- 48/16/b Radar Attack Sources of Error. E.K. Williams, July 1969
- 48/16/c Nomogram relating Radius of Turn, angular rate of turn, angle of bank and true airspeed

(48) (EKW 17) CRT Improvements, Phosphors, Colour

The WWII produced a rapid development of special tubes to meet Radar demands. Long persistence was no longer determined by ad hoc natural compound selection, but with the production of intense blue, bordering on ultra violet phosphors, the way was open to induced fluorescence (or phosphorescence) and two layer tubes became the norm for surveillance radar use, whilst improved green and blue very low persistence tubes also became available.

With several companies in UK producing their own variants on a theme, CRT Standardisation was a most pressing requirement, and by December 1940, this had been achieved, and magnetic scan 9" and 12" PPI's were available. It took a little longer to standardise the 12" electrostatic tubes, and it took until 1943 to gain some degree of standardisation. Bases of CRTs were standardised by 1941. Even so, because all the pre 1941 Oscilloscopes and displays used a variety of old tube styles, there had to be a limited production of all these during the war. Thus STC, Cintel, Cossor and EMI were all producing limited numbers of the old types as well as new ones.

Following the wide reviews of the Services, of their requirements for the post war years, it became obvious that the makeshift arrangements and designs of the war years would have to be revised. Cathode ray tubes were amongst the items for a radical change. New research on phosphors by 1950 produced prototypes of new PPIs with self coloured 'flash' and afterglow ... Iodide compounds, giving intense orange flash and afterglow which could extend to minutes. The standard PPI from then gave a tenth brilliance after some twenty seconds, but still was visible after 2 minutes, giving for targets etc tracks of some minutes.

This then is the background to the revisions in CRTs in the post war years.

- 48/17/a A Question of Colour: a review by E.K. Williams of the uses and advantages (or not) of coloured Screens. 1980
- 48/17/b Projected map displays. Bendix Information Sheets 1969
- 48/17/c Phosphor Characteristics. Handwritten list of Phosphors and their characteristics. July 1971
- 48/17/d Research into thin layer CRT Screens. E.K. Williams. A Ferranti CVD Research project. 1959
- 48/17/e As (d) above but report date November 1960
- 48/17/f Letter from EKW to Ferranti, re transparent phosphors. Dec 1958
- 48/17/g AGARD Report. Multicolour displays using Liquid Crystal colour switch. Shanks, RRE 1975.
- 48/17/h Rank Cintel Brochure. Cathode ray tube Design. Undated
- 48/17/i High resolution phosphor screens. Beesley & Norman. Advances in Photoelectric Image devices and Electron Image Physics, 1965
- 48/17/j Some measurements on direct recording of electron images using thin windows. Wheeler & Emberson. Advances in Photoelectric Image devices and Electron Image Physics, 1965
- 48/17/k Patent Spec 965902. Improvements relating to transparent luminescent screens. Ferranti. Turner, Woodcock, Cresswell & Meyer, 1964
- 48/17/l Transparent Phosphor Screens. King (GEC) J. Tel Soc. Mar, 1962

48/17/m	High Resolution CRTS. Allard. <u>Med. & Biol. Illust.</u> , July 1964
48/17/n	Photo of High resolution CRT Map, superimposed land map.
48/17/o	Shedding some light on optical measurements. Zana. <u>Electronics</u> , Nov. 1972
48/17/p	Light Units. Mullard. From a Data Sheet.

(48) (EKW 18) Target Recognition & Ship Classification

Even in early days of Gun Laying Radar, using the new 10cm equipment (GL3), operators became quite proficient in recognising visually on the cathode ray tubes, whether the aircraft being tracked was a Spitfire, Tempest, Hurricane, or a bomber .. Wellington, Lancaster, Flying Fortress and later, the easy job of recognising the new Jet aircraft, simply from the type of fading or the pattern of amplitude variation on the fine (i.e. not the coarse) range tube, where the returned pulse was spread out. With the advent of computers, the process has been removed from a personal training basis to a 'mechanical' one.

- 48/18/a Visual aspects of Ships. This appears to be a limited selection of ship types portrayed in a Manual. The Source and date are not known
- 48/18/b Target Characteristics. Bardo. From 'Radar 74'. Dec 1974
- 48/18/c Ship Classification. E.K. Williams. Summary of a Naval Weapons Centre report on their 'Classifier'. Dec 1980
- 48/18/d Automatic Ship Classification. Summary of NWC report on Flight Trials. E.K. Williams, April 1981
- 48/18/e Further studies in Ship Classification: Merchant Ships. E.K. Williams, Aug. 1981

(48) (EKW19) Radar Requirements for (Castle Martin) Test Site.

These papers particularly highlight the problems of personnel using facilities to do their legitimate jobs, in this case to provide safety cover for shipping within a Test Firing Range, when they are not fully versed with the theory behind the equipment they are required to use or of the equipment's natural limitations. The equipments have been specified at a lower level than the conditions of operation warrant (High Wave Heights) under which they are to be used.

See also File on Sea Clutter. File 48 (EKW12)

48/19/a	RAC Castlemartin Radars. EKW, 31 Jan 1979
48/18/b	Notes on a visit to Castlemartin, Feb 1979
48/19/c	Performance problems of Castle Martin Radars. EKW, March 1979
48/19/d	Notes on sea states etc. at Castlemartin 1977/78
48/19/e	Handwritten list of suitable References. (Many are in File 48 (EKW12))
48/19/f	Handwritten Memo ?Possible solutions?

(48) (EKW 20) Aspects of Doppler

- 48/20/a Doppler Beam Sharpening in forward Looking Radar. Cruickshank. RRE. Jan 1967
- 48/20/b SECOND Addendum to note on Forward Looking Doppler Beam Sharpener. Corless. June 1975
- 48/20/c Descriptive paper re a General Electric Doppler Beam Sharpener (DBS) with a non coherent magnetron type transmitter. No date
- 48/20/d Synthetic Aperture Radar Spotlight mapper. Brookner. Being Chapter 18 of un-named book or Magazine
- 48/20/e Effect of Sea Bias and Wave movement on accuracy of Doppler. Thorne. Sept 1973
- 48/20/f Doppler Correction for Surface Movement. Grocott. (Reprint) J. of Nav., Jan 1963
- 48/20/g Doppler Navigation. Clegg & Thorne (Reprint) IEE Proc., Vol.105 Pt. B Supplement No. 9 1958
- 48/20/h Design of DBS Mapping Mode. Ferranti. No Author or date
- 48/20/i Generalised Clutter Computation for Airborne Pulse Doppler Radars. Friedlander & Goldstein. IEEE Trans. Aerosp. & Electr. Syst, Jan 1970
- 48/20/j Decca Doppler Type 72 Brochure
- 48/20/k Performance of Decca Doppler 71 & 72 in Rain. Decca Report. No Author or date
- 48/20/l Notes on Decca 72 Performance Billings. RRE 9 Sept 1972
- 48/20/m Decca Letter to EKW re Decca 72 and 'Bright Band Locking in turns.' Gray. Decca, May 1974.
- 48/20/n MTI and Tracking N. Am. Av. Frost. Jan 1967. Explanatory Note.
- 48/20/o Handwritten (EKW) notes on Strike and Reconnaissance Policy. No date
- 48/20/p Forward Looking Doppler Beam Sharpening. Corless. RRE, April 1975
- 48/20/q Some thoughts on the aftermath of 'Red Neck'. Cary. Feb 1962
- 48/20/r Bibliography of Reports associated with High Resolution Radars. General information
- 48/20/s A CCD Saw Processor for Pulse Doppler Radar signals. Roberts, Eames, Simons. RRE. No date
- 48/20/t Geometric azimuth errors...

(48) (EKW21) Synthetic Aperture Radar

Synthetic Aperture Radar, Cutrona. Copy of Chapter 23 of unspecified book or Magazine.
Theory of Ground Mapping Radar

(48) (EKW22) Bruneval.

Bruneval is a small village/township on the North coast of France. In 1942, a new type of German Radar was noted there, close to the cliff top in reconnaissance photographs. It was regarded as imperative by TRE, the RAF and Army, that more should be found out about this new radar type, and a Special Services raid was authorised, intended to capture important parts of the Radar, any documents, and if possible, prisoners. There are many detailed accounts of the raid, particularly the account of the Combined Forces part, in 'Combined Operations', HMSO 1943 (See File 49), and 'Most Secret War' by R.V. Jones (Hamish Hamilton, 1978 & Wordsworth Edn, 1998 Chap.27).

The papers in this file relate to the aftermath of the exercise, after TRE and RAE (Farnborough) had examined the returned equipment and evaluated it. There is a description of the finds, and a series of photographs of the equipment along with some circuit diagrams (all indexed in the text). There was a previous report with initial details, but no copy has been located by EKW or DHT.

See also File 50, for a description of the full equipment, the 'Wurtzburg', the German anti-aircraft radar

(48) (EKW23)

Historic letter suggesting the need for a Pathfinder Force to assist in the accurate dropping of troops during the forthcoming Invasion of Europe. Dated 19 July 1943.

This Letter is NOT from a recognised Member of the RAF, but from a Member of TRE, who had been given an Honorary Squadron Leader Rank, to allow him to accompany Airforce raids and take an active part in planning. He was J.W.S.Pringle, who was responsible later for setting up some of the Spoof raids in the Calais area, to draw off enemy forces from the real invasion. He and Trevor Moss and others from TRE accompanied the aircraft and ships carrying the Spoof equipment generators, to ensure their correct working since they were unique equipments, not in Service use. He was closely connected with the Rebecca/Eureka development, hence his suggestion for its use (or similar special equipment) to assist his proposed Pathfinders in the invasion.

As far as DHT knows, this document has never been published. It is of course by now unclassified.

(48) (EKW24)

RADAR, the story of those who developed the instruments for RAF use, 1935 to 1939 and on to 1945.

In August 1945, immediately after the defeat of Japan, the story of RADAR was released to the Press in UK and USA. The story in general gave a very good picture of what Radar was, and how it had been used. Only short mentions were made about the people who had thought up, devised and made it work efficiently.

E.K. Williams in October 1945, wrote these words about the PEOPLE, whom he considered were entitled to be remembered for what they did, often under difficult circumstances.

It was never published!

To some extent, much later, Ed Bowen, in 'Boffin' extended these thoughts.

DHT, 2002

(48) (EKW25)

Collection of brief handwritten notes by EKW.

- 48/25/a Radar signal detection probabilities
- 48/25/b Introduction to Radar Systems. Notes on aspects of radar detection and various sources of information
- 48/25/c Sea Clutter
- 48/25/d List of information sources, mainly concerned with Sea Clutter
- 48/25/e Weather: Atmospheric attenuation at X, Ku & Q Bands
- 48/25/f Radar cross section
- 48/25/g MTI
- 48/25/h 'Chaff' also known as 'Window'

(48) (EKW 26)

Analysis of Wire Strikes by Helicopters, 1964 to 1972

An analysis of types and causes of helicopters hitting overhead cables, by Fl Lt Cooke.

(48) (EKW 27)

Interavia List of Airborne Radars

Reprint from 'InterAvia' of data on a large number of Aircraft 'Nose' radars (Commercial) for ground surveillance, weather assessment, target detection, tracking & weapon control, and an ever increasing list of objectives (As at 1981)

(48) (EKW28)

Radar Navigation, R.A. Smith of TRE

Reprint of a lecture at the IEE Radiolocation Convention 1946. R.A. Smith was the Wartime Head of TRE Airborne Radar Division.

This paper was of tremendous importance, as it led the way for consideration of the application of radar and radar based electronics to civil aircraft, airways and airfields, as well as military systems. Many of the ideas thrown up by wartime (often crude) systems were to be adapted and adopted over the following 5 years, leading to a revolution in navigation methods, still being further advanced in 2002

(48) (EKW 29)

Airborne Radar Future: A Personal View

This is an in depth appraisal of the different roles of (military) aircraft, and the associated requirements for radar and associated electronic systems. EKW did not include civil aircraft, leaving such considerations to commercial organisations, since these either followed closely on military systems where applicable, but stripped of all unnecessary facilities not required in the civil world of 1980

(48) (EKW30)

Effect of Clutter on direction finding Systems employing comparison methods

Reprint of an IEE lecture paper of 1972 by D.C. Cooper (Birmingham University & late of RRDE) and I.D. Longstaff (RRE)

(48) (EKW31)

High Resolution Radars (Airborne) a collection of papers

- 48/31/a A preliminary Note on Forward looking Strike Radars for Advanced combat aircraft. 1966
- 48/31/b General note on High Precision airborne radars. 1979
- 48/31/c Critical comments on a Sea Harrier report (original report not available)
Contains important parameter discussions
- 48/31/d Notes on Sea Harrier Radar performance
- 48/31/e Problems arising from Euro Fighter Contracts. International contracting for NATO or similar Equipment always introduces problems of National Security, in that bids are overseen by Nationals of all participating parties, and therefore it is often feared that 'secrets' of any one country or firm might become general knowledge. This paper analyses some of the problems
- 48/31/f Tornado Radars
- 48/31/g Notes on a UK Management Board Meeting re Navigation aircraft needs. 1967
- 48/31/h Letter giving parameters for alternative requirements for the above 97) aircraft

File 49 (KM)

This is a collection of files, passed to DHT by the widow of Prof K. Milne OBE for safe keeping, in years 2003/4, via Ian Shaw, late of TRE and DERA, and Prof. P.D.L. Williams C.Eng, FIEE FRIN, who provided this introduction.

DHT has added a further note at the end, showing his connections with Ken Milne over the years.

The files are all numbered File 49 (KM ...), with a serial number, but it has not been possible to group them under subject headings, partly because they are only being provided to DHT in batches and it is necessary to deal with each batch independently.

Introduction

These notes were compiled in 2004 by Prof.P.D.L. Williams C.Eng. FIEE FRIN, late of industry and a Visiting Prof. with the Open University and then the University of Leicester and A.H. Shaw C.Eng MIEE formerly of Telecommunications Research Estab. (TRE)

They provide a guide to a collection of the private working papers saved by Professor Kenneth Milne OBE, both before and after his move from Havant to Kenilworth and after he reduced his once considerable collection of technical papers.

The dates and essential details are from his CV kindly made available by the Royal Academy of Engineering in 2003 in pdf format [1226160905].

His career was spent with various firms, then as a well respected private consultant and as a Visiting Professor at University College London with Professor Hugh Griffiths.

Early Life and Education 1939 to 1946

He was born in November 1925 and attended the Royal Grammar School in Newcastle-upon-Tyne before serving as an engineering apprentice with the BTH Co. Ltd. Rugby during World War II.

During this period he also studied at Rugby College of Technology and Art gaining a B.Sc (Eng) in 1946. His well-kept College notebooks for this period are included as part of the collection.

He gained his Ph.D. in 1951. The outcome of his research work later formed the basis of the Plessey AR3D, an Early Warning radar providing target position in height as well as plan position. Early published papers and Janes Weapons Systems give technical descriptions.

Briefly this novel radar achieved 3D scanning as the rotating reflector antenna was fed by a vertical dispersive array, so with frequency sweep (Chirp) inside each transmitter pulse both electronic scanning, pulse expansion then compression was achieved.

Initial Career in Industry 1951-1978

After the war he continued as a design engineer at BTH (which later with Metropolitan Vickers became AEI, then merged into Marconi and later into the GEC Group).

Limitations of this collection

We surmise that Professor Kenneth Milne over the bulk of his career may have spent his time as follows:-

- 30% on MOD Classified Projects. There are no records of this work in this collection, (although some records may be released by the National Archives).

- 25% on Company projects which at the time were regarded as Company Confidential.

20% on AGARD work, some papers being published in the open literature by AGARD, others being classified in some way at that time.

So a great deal of Professor Milne's work is no longer readily available.

A similar situation pertains with regard to the research records of British Thomson Houston Rugby, Metropolitan Vickers Trafford Park, Plessey Radar Havant and IoW and Decca Radar's extensive labs at New Malden, Tolworth, Davis Road and Hersham. BTH and MetroVic were absorbed into GEC, together with all the Marconi companies including the research labs at Great Dunmore and valve work at EEV Brown Lane.

BAC Space Systems has a similar history of mergers in the same way that Decca Radar with Racal in general became part of THALES itself a part of French CSF.

In much the same way the Government Research Establishments TRE and RRDE; ASWE and AUWE; SERL and RRE: RAE were all combined into DRA, later DERA and finally (as at 2004) into QINETIC, and most of the old papers and records have been destroyed.

To help future researchers we suggest that these papers are read in conjunction with other collections and the following list of new technologies as they emerged in the open literature and bodies such as the USA association of "Old Crows" devoted to EW, ECM, ECCM ..

Birmingham University was a centre of excellence in Sonar whilst things like Pulse Expansion and Compression were commonplace in the 1960s.

Open literature sources such as Radar Technology Encyclopedia, ed. D.K. Barton (Artech House Inc, 1950) and later technical information by Skolnik, Swerling, Blake and by Bruckner can be consulted.

Other papers in this field are listed in 'Military Science and Technology' in the archives of Churchill College, Oxford.

A general history of the development of Ground Radar for Air Defence is given in 'Watching the Skies' by Jack Gough (pub. HMSO 1993 ISBN 0 11 772723 7), although this is specifically based on minutes and other papers of high level committees which have been deposited rather than the true practical situations (DHT).

This includes details of the code names and service designations of the various radar types mentioned below.

Whilst at BTH, Dr. Milne specialised in microwave antennas and radar systems contributing to the development of a 3D antenna for air surveillance employing a horn stack feed with a mirror-lens combination, code named Orange Yeoman being designed at RRDE (later RRE North site) and subsequently manufactured by Metropolitan Vickers

A note from Dr. W.H. Penley dated 28/11/03 states:

'When TRE and RRDE were combined to become RRE in 1953 I was head of the new Guided Weapons Department. The R&D for tracking radars was one of the activities, and major contracts were with the BTH. I remember Ken Milne as a very significant member of the team under Bill Melville dealing with the more advanced aspects of design both for multi frequency (S & X band) pulsed equipments for gun control and the Mark 1 SAGWs and the CW sets developed for Stage ½ SAGW. I think he was also involved in the design BTH submitted for the satellite communication equipment for Goonhilly Down - but this failed to get the contract - the mechanical design for the aerial by a Civil Engineering Consultant being preferred to the multi-axis tracking aerial proposed by the BTH. At this time the leaders of my team at RRE were John Clare (who became European Vice President for Raytheon)

and Jock Marsh who became Technical Director of STC. Unfortunately they both died some time ago. (BP)

Bill Penley's note refers to the gun control radar Yellow River used for target tracking and illumination for the Thunderbird and Bloodhound missiles as AANo3Mk9 (Army) and Radar Type 83 (RAF).

The CW tracker and illuminator Radar, Blue Anchor was designated as Radar type 86 (RAF).

In 1960 Dr. Milne joined Decca Radar at Tolworth Surrey and was responsible for an initial C.W. search radar design for a projected SAGW project PT428.

Dr. Milne contributed to novel schemes for improved channeling arrangements for accessing communication satellites from a number of ground stations.

Dr Milne joined Plessey Radar on the South Coast later becoming their Director of Research. Here he conceived a novel form of 3D radar combining pulse compression with electronic scanning in the vertical plane in each pulse length. This highly sophisticated AR3D radar sold to an international market.

In 1968 he was responsible for the design of Britain's first naval satellite communication terminal and subsequently for installation on board HMS Fearless and HMS Intrepid.

In 1973 Dr Milne was on the Organising Committee of the IEE radar conference 'Radar present and future' (IEE CP105 1973) which followed the first IEE Radar conference in 1946, shortly after the end of World War II (IEE Vol 93A 1946) which reviewed most of the war time developments in radar. The list of authors in the 1973 papers shows many of his colleagues worldwide.

He was honoured as an OBE in the 1975 New Year's Honours list for services to exports.

In 1977 Dr Milne chaired the next in the IEE-IEEE series of Radar conferences held in a 5-year cycle in America and UK. He also gave a paper on Multistatic Surveillance Radar. The proceedings of this RADAR 77 conference are published as IEE CP no155 1977.

In 1977 Dr Milne left Plessey to become an independent electronic systems design consultant and also a Visiting Professor in the Electronic and Electrical Engineering Dept at UCL. Here Professor Milne made many more friends and steered lots of young engineers on the straight and narrow path with good humour which they will remember all their lives. One of these became Professor A.K. Brown at Manchester University.

At the next IEE RADAR 82 Conference CP no 216 Professor John Forrest gave a paper on bistatic radar using the Heathrow ATC radar as a "free illuminator" and his first reference was to Dr. Milne's paper in 1977.

In 1983 Dr Milne contributed to and then carried out the final edit on a two-volume book 'The Handbook of Antenna Design' by A.D. Rudge, A.D. Oliver, K. Milne & P. Knight (pub. by Peter Peregrinus in the IEE EM Wave Series).

In 1985 'Advances in Radar Techniques' ed. J. Clarke of RSRE IEE EM Wave Series 20 included again Dr. Milne's paper 'Principles and concepts of Multistatic Surveillance Radar'.

Prof. Milne gave his paper on 'Prediction of Sea Multipath fading Characteristics' at the Radar87 conference IEE CP no281. This illustrated his wide field of activity in Antennas, Radar, Propagation and unwanted backscatter or Clutter, all essential facets of many radar systems. Each of his papers gives many references from people he had worked with.

In 1992 Professor Milne formally retired! But still carried on sorting out friends' problems. We are sure that many authors of papers for future Radar series meetings will have asked for

his help and opinion and received a gracious response. He sat on both IEE and IEEE committees and some of the relevant papers may exist.

He also served for many years on Nato NIAG and AGARD panels and committees and arranged a conference on Battlefield Surveillance and Target Acquisition Sept. 1974 Ds-DPL (74) 264.

This list is by no means complete and a biographer will find out more about the life and work of Professor Milne.

Audrey his widow has been most helpful and is keen to see the papers pass to a responsible body.

In addition to all Professor Milne's academic work he was particularly innovative with the early PCs. As an example with a 32k memory PET PC he wrote his own word processor that was used for many years, the external memory used music cassettes.

His hobbies included the PC control of model electric trains and of music. He was a keen musician and himself played the piano. He was also a good artist and his sketches were worth many words.

The Bench Marks in his career should enable any future biographer to research and publish a biographical record to assist both future young radar, communication, and other electronic engineers. Historians may also gain an insight not only into Professor Milne's career but into the teaching of a whole generation of young engineers during the many stages of their careers.

Donald H. Tomlin B.Sc. C.Phys. Minst.P. adds a note to indicate why he is pleased to include Ken Milne's papers in the Radar Archive in the Sheffield University Library Archives.

DHT first met Ken at BTH in 1944, where as an apprentice, he was doing a stint working in the Research Labs at BTH, Rugby.

BTH had been responsible for the development of the first Army centimetric Radar, AA No3 Mk2, better known as 'GL3' (Gun Laying No 3). The previous AA radars had been GL1 and GL2, both operating in the metric part of the radio spectrum. The GL3 was a manually controlled radar in bearing, elevation and range. From its inception in 1943, it had always been recognised that it was desirable (for saving manpower, and also to improve tracking accuracy) that such radars should be made to automatically track targets. At ADRDE, at Malvern, work was put in hand by J.M. Robson, and a very satisfactory but extensive modification was developed which reduced the manpower required, to one, the range operator, and at the same time the accuracy was approximately doubled. DHT was responsible for developing the electronic circuits as designed by Robson, into a practical 'Add on Kit', and six sets were produced and fitted to prove the system. BTH were then given a contract to produce the kits more or less as designed by Robson and DHT, but they jibbed at using aircraft generators, modified to become split field motors, and at using open gear trains from the motors to the existing gear rings on the original equipments. Ken Milne was given the job of delineating the requirements in terms of BTH standard Motor frame and working with Dr Bowen, the BTH Chief Mechanical Engineer, producing satisfactory low inertia and low friction oil filled gear boxes. The whole was very satisfactory, but it was too late in the War to contemplate wholesale equipment modification. Also, by that time the American Auto track set, SCR 584 was in widespread use, and BTH had produced by crash program action, a very small, highly mobile auto track set, AA No 3 Mk4 albeit using components which could be located on surplus to requirement manufacturers stock, not necessarily to specification, but which produced an acceptable end result. BTH had been encouraged in this

unorthodox approach by being offered the carrot that they would be given a contract later to produce a fully proven system using orthodox components. Ken was associated with this latter exercise, mainly in vetting drawings and designs.

In 1949, following the extensive testing of lens aerials by E.G. Brewitt Taylor at RRDE, BTH were given a development contract to develop the proposed new Army surveillance radar operating in '3D'. This was to become Orange Yeoman, later to be the Radar Type 82 for the RAF. (In 1952/3, the Air Defence of GB was transferred from the Army to the RAF, and AA Command was disbanded). Ken Milne was associated with a lot of the aerial testing at Church Lawford, the BTH aerial test site near Rugby, and in particular for devising along with Dr Bowen, a suitable suspension system for the row of parallel plates which formed the lens aerial. The first of these lenses was handed over to Metropolitan Vickers at Trafford Park for use on the first prototype of the full set, installed at Frodsham in Cheshire. In 1950, BTH had been encouraged to take on the development of the new proposed fully autotracking AA radar which later was to become the Type 83, but BTH felt that they could not fulfil both the AA radar and the surveillance radar developments with their existing facilities, and negotiated for the surveillance radar to be passed to Metro-Vickers, working with them to gain an understanding of what had already been researched at Rugby.

I next met up with Ken at Decca, briefly, when I was evaluating the proposals for the Decca designed HF 200 nodding height finder, as a possible RAF radar to replace American designs. Much later, when he was at Cowes IoW, I met him again when Plessey (who had taken over Decca) had a development contract to improve the overall performance of the HF200 sets in RAF hands.

In 1984/85, after I had retired, we were both involved in the arrangements for the 1985 IEE Symposium celebrating the 50th anniversary of the setting up of the 'Tizzard Committee' and the subsequent 'Darent Experiment'.

I remember him as a very shrewd engineer, and as some of the papers show, a very competent mathematician and later a fully computer-literate engineer. He was always gentlemanly in his approach to staff and visitors, and always treated everybody with respect. I do remember my first meeting with him at Cowes, after many years, when he came to listen in at a technical meeting I was chairing. When he came in, he came to me and shook hands and exclaimed, 'We seem to have met before ... Don ... even back in distant history'. He then explained to his staff, still holding my hand that 'We had first met in the late War, when he (Milne) was a very wet apprentice.' (DHT)

(49) (KM 1)

As an Apprentice at BTH (British Thomson Houston Co Ltd) Ken Milne would have been required to attend appropriate courses, and for Electrical apprentices, this would have been in either the BTH College (if suitable numbers of people were available for specific courses) or in the Rugby College of Technology & Arts. Many of the lecturers at the latter were in fact senior staff at BTH or English Electric Co, which had a major works also in Rugby.

This is his Engineering notebook of 1943 to 1945 covering mainly Theory of Machines, Thermodynamics and Fluids.

See also File 49 (KM2)

(49) (KM2)

Ken Milne's Notebook at Rugby College of Technology and Arts, from October 1945 to March 1946, covering the Design of Electrical Machines.

(49) (KM3)

A collection of copies of technical papers by K Milne at various dates. Some are original typed copies, others copies of published articles. The subjects are mainly Radar or Communications and cover Aerial Design (lens, planar and phased arrays etc.), pulse compression, signal correlation and an early look at computers.

(49) (KM4)

A collection of Technical Publications each with an article by K. Milne.

49/4/a I am an Engineer .Independent Television for Schools, Spring term 1989

49/4/b Journ. Roy. Astronom. Soc., June 1962. The economics of Astronautics

49/4/c Journ. Radar & Electronics Assn., March 1963. Survey of Microwave Aerials for Radar and Allied Applications

49/4/d Journ. Electronics & Radio Eng., Aug 1964. Combin. of Pulse Compress. & Frequ. Scanning for 3 Dimens. Radars

49/4/e 1989 National Electronics Rev. (N. E. C.) . Pers. Computers for the 'One Man Band'

49/4/f Journ. Royal Navy Scientific Serv., Jan 1969. Naval Satellite Coms. (with G. Harries)

49/4/g Electronics & Comms. Eng. Journ., Dec 1989. Radar and Antennas Pt. 1

49/4/h As (g) above. Feb 1990. Pt. 2

49/4/i IEE Rev., Dec 1989. Pers. Computers and the 'One Man Band'. (See also (e) above)

(49) (KM5)

Lens Aerials. Lecture notes and OHP transparencies (KM)

Where delivered, not known.

Also: copy of paper, Journ. Rad. & Electronics Eng. Vol. 52 No. 4 April 1982. 'Des. Cons. for Ruze & Rotman Lenses'

(49) (KM6)

49/6/a Copy of paper re. Wide Angle Microwave lens for Line source applications. Rotman & Turner, IEEE Trans. Anten. & Propn. Aug.1962.

49/6/b Microwaves. Sept 1982. Copy. Numerical methods make Lens Ant. possible. J.J.Lee Hughes Aircraft.

49/6/c Notes & Diagrams re. 'Alternative multibeam aerials'

49/6/d Appendix to a paper on Wide-angle scanning path length lenses

(49) (KM7) Microstrip Lines

49/7/a Copy of paper. Microwaves, Optics & Acoustics. Jan 1979. Vol. 3 No. 1. 'Average Power Handling capability of Microstrip lines'. Bahl & Gupta

49/7/b Original IEE Journ. Microwaves Optics & Acoustics, Sept 1977
Contains:

Microstrip antennas & Arrays Pt. 1. Fundamental action & limitations, James & Wilson

Microstrip antennas & Arrays Pt. 2. New Array Design Techniques. James & Hall
(Des. Rx Stns. satellite to ground propag. research at frequ. above 10Ghz. Allnutt & Goodyer

and: Transmission line matrix analysis of continuous wave-guiding structures using stepped impedance. Sitch & Jones)

49/7/c Proc IEE Pt C Feb 1960 Monogr. 358E. Radiation from discontinuities in stripline

(49) (KM8)

Copy paper IEEE Trans. Antennas & Propagation March 1970. Theory of Mutual Coupling among Minimum Scatter aerials. Wasyliwskyj & Kahn.

(49) (KM9)

Homogeneous plane waves in lossy dielectric.

Manuscript notes & diagrams (KM)

(49) (KM 10)

A collection of papers each dealing with a different aspect of propagation.

- 49/10/a Propagation of EM waves over irregular terrain, King (BBC Research Dept) & Page (Imp. Coll. of Sc. & Tech.) Printed paper with no indication of whether or where published, nor date. Deals comprehensively with problems of radio broadcasting 50 to 1000Mhz. Useful Bibliography
- 49/10/b Propagation in a medium in which refractive index changes with height. Handwritten by KM. No date, but possibly around 1970-76. KM was the leading engineer behind the Plessey AR3D Radar, a 3 dimensional sensor, and the derivation of accurate height of aircraft etc above the earth's surface is dependent on the refractive index, and its gradient. Similarly, the height accuracy of the HF 200, the standard RAF nodding height finder was dependent on the refractive index, but had previously not been taken into account. During the development of proposals to update this radar in the 1970's, the Plessey Engineers were looking at means of taking into account corrections for the classical gradient, and also means of using locally generated variants of the gradient. KM took considerable interest in the proceedings on both accounts
- 49/10/c Multiple knife edge diffraction of microwaves. Degout. Copy of article in IEEE Transactions on Antennas and propagation
- 49/10/d Diffraction by Cylindrical Reflectors. Prof R Plonsey. IEE Proceedings Pt C Jan 1958. Monograph 281R. Read before IEE Radio Section 5 Feb 1947. Based on an ASE Report Sept 1942 (no doubt classified at that time. Of importance in both Communications and Radar)
- 49/10/e A single sheet (typed) unasccribed, but possibly KM. May be part of a larger treatise, but no indication. Obviously part of a Satellite problem. Headed 'Problem with flat earth assumption'
- 49/10/f Propagation beyond the Horizon. Manuscript. Totally mathematical treatment
- 49/10/g Over the Horizon Propagation. Manuscript. Totally mathematical treatment. Pencil heading note refers to Kerr and references to pages 96, 97 & 122-125.
- 49/10/h Extraterrestrial radio noise and its effect on radar performance
- 49/10/i The calculation of field strengths over a spherical earth

(49) (KM 11)

Modern inertial navigation technology and its applications.

Western & Titterton, Electronics & Communication Engineering Journal, April 2000.

Original copy removed from magazine.

(49) (KM 12)

- 49/12/a Full copy of IEE Proceedings F Communications, Radar and Signal Processing. Vol. 129 Pt. F No. 1, Feb 1982. See marked index at rear cover. cf Fresnel ripples on sidelobe suppression related to Linear FM Pulse compression.... Evaln. of sidelobe cancellor performance ... Performance of recursive MTI filters (finite samples) Branched ducts and transmission lines
- 49/12/b Unassigned typed paper on Use of CHIRP Transmitters to improve EMC between radars. (KM ?) Undated
- 49//12/c Reprint of paper in The Radio & Electronic Engineer, Aug. 1964. Symposium on Signal Processing in Radar & Sonar Systems, Paper 5 'The combination of Pulse Compression & Frequency Scanning for 3D Radars', K. Milne

(49) (KM 13) Trough Waveguide

- 49/13/a Manuscript notes (KM) on waveguide modes
- 49/13/b Asymmetrical Trough Waveguide Antennas. Rotman & Oliner. (Publication source not known, but paper submitted June 1958)
- 49/13/c Periodic structures in trough waveguide. Oliner & Rotman. (Publication as (b) above)
- 49/13/d An Electromechanically scannable trough waveguide array. Romn & Raestry. (No printed reference to source, but manuscript note 'Interim Conv(?) Records Pt. 1 p. 67-83 1960)

(49) (KM 14) Waveguide calculations

49/14/a Manuscript (KM) Considerations of proposition at Markovitz, pages 296-300
(Discontinuity in waveguide)

49/14/b Computer program: Reflection Coefficient for Symmetric H-Plane Waveguide
Junction for differing waveguide widths (2 parts)

(49) (KM 15)

Personal (KM) considerations of mathematics and practicalities of Digital Filters:

Quantisation effects

No indication whether published

(49) (KM 16) Surface Waves

- 49/16/a Single Conductor Surface-wave Transmission Lines. Goubau. Proc IRE 1952 (p. 619 et seq.)
- 49/16/b Reflections from a cylinder in a surface wave field. Typed paper with footnote, by Cullen, Davis & Leppington. In a tail-note it is stated that it is hoped to publish full mathematical analysis and experimental results later. Undated, but a reference is dated 1975
- 49/16/c Excitation of surface waves. Friedman and Elwyn Williams. Proc. IEE Pt. C

(49) (KM 17) Wire Grid Modelling. The process of deriving recognisable current (or other parameter) in surfaces etc.

49/17/a Handwritten note on 'Method of Moments' (KM)

49/17/b The Integral Equation method. A Chapter from an unspecified book, in typed form. The last section of the chapter is headed 'The Point Matching Solution for Wire Grid Bodies'

(49) (KM 18) Back-scatter (Mainly sea wave scatter)

- 49/18/a Description of a sea state sensor 'MIROS' (Microwave sensor for the Ocean Surface)
- 49/18/b Typed and handwritten notes referred to as 'Working Paper'. Covers:
Fresnel reflection coefficients for smooth sea,
Some Ocean statistics
Effect of rough sea on specularly reflected component
RMS Wave Slope v Wind Velocity
Glistening surfaces
Ricean Power Distribution
Statistical nature of signal received in the specular direction from rough sea
Variation of path length across observer's beamwidth
- 49/18/c Similar notes, but with 'key' EWP/12/EM. Subjects covered:
Reflections from an infinite sinusoidal corrugated perfect reflector
Variations of grating lobe angles with 'sea Wavelength'
Principal echoing areas from sinusoidal corrugated plate
Reradiation from sinusoidal corrugated plate close to Bragg resonance
Backscatter from rough surface
Properties of Ocean Waves
Alternative forms of the same non-directional sea wave spectrum
Directional Spectrum used to calculate specific echoing area
Commonly used form of directional wave spectrum
Predicted B/S at low grazing angles (Vert. Pol.)
Radar Equations to determine received signal power
- 49/18/d Studies of Sea using HF Radio Scatter. Teague, Tyler & Stewart. IEEE Transactions on antennas and propagation, Jan 1977
- 49/18/e Full Wave & Physical Optics solutions for scattered radiation from rough surfaces. Bahar. IEEE Transactions 4 July 1978
- 49/18/f A Kirchhoff Backscattering model for rough surfaces. Dong & Cashman. Copy of first issue m/s
- 49/18/g Backscattering from Gaussian-distributed perfectly conducting rough surface. Gary Brown. IEEE Trans Ant & Propn. May 1 1978
- 49/18/h First Order Theory and Anals. of VHF, HF, MF scatter from sea. Barrick. IEEE Trans Ant/Propn. Jan 1972.
- 49/18/i Rough surface scatter from specular point theory. Barrick. IEEE Trans Ant & Propn. July 1968
- 49/18 j Remote sensing of sea state by Radar. Barrick. Copy of chapter from book 'Remote Sensing of the Troposphere' 1972
- 49/18/k Average impulse response of rough surface and its applications. Gary Brown. IEEE Trans Ant & Propn. Jan 1977
- 49/18/l The Statistics of HF Sea Echo Doppler Spectrum. Barrick & Snider. IEEE Trans Ant & Propn. Jan1977

- 49/18/m KM Note re Specification of clutter for low-level radars operating at 1-20 Ghz
- 49/18/n Radar returns at near vertical incidence. Moore & Williams. Proc IRE Feb 1957(?) Radar Altimeters

(49) (KM 19) Circular Apertures

- 49/19/a Paper, no indication of publishing or reading. Shaped patterns from a continuous planar aperture distribution. Elliott & Stern. No date
- 49/19/b Manuscript examples and notes (KM)
- 49/19/c Circular Aperture Synthesis. Ruze. IEEE Trans Ant & Prop. Nov 1964
- 49/19/d Manuscript notes 'Separable feedHorn illumination' . No date
- 49/19/e Manuscript notes. 'Overall Gain Factor'. No date
- 49/19/f Manuscript notes. 'Radiation Pattern'. No date
- 49/19/g Manuscript notes. 'Power intercepted'. No date
- 49/19/h Manuscript notes. 'Power in main beam'. No date.
- 49/19/i Manuscript notes. 'Circular aperture ... Assymetrical illumination'. No date
- 49/19/j Manuscript notes. 'Effective aperture'. No date
- 49/19/k Manuscript notes. 'Expansion in series of Bessel Functions'. No date

(49) (KM 20) Beam Forming (Multi-beam Systems)

- 49/20/a Typed Paper. Investigations into Beam Forming Networks. K Milne April 1983
- 49/20/b Theoretical Limitation on the formation of Lossless Multibeam in Linear Arrays. Allen. IRE Trans Ant & Propn. July 1961 (?)
- 49/20/c Phased Array Beam Steering by Multiplex Sampling. Johnson. Proc IEEE Nov 1968
- 49/20/d Beam Stacking Problem in Volumetric Scanning Radars. Milne & Van der Haut. Plessey Radar Report HRL426 16.11.61

DHT note: By 1961, Orange Yeoman was in service with the RAF as Radar Type 82, with 11 stacked beams, with very low interaction albeit with single frequency working, but capability of accepting standard magnetrons with reasonable frequency spread (Manufacture tolerances). KM had been part of the aerial testing group at BHT. By 1961, much of the preliminary design work had been done by RRE and MV Co. for Radar Type 85, embodying a 12 beam stacked system, with full transmitter/horn access interchange and multi-frequency agility.

(49) (KM21) The Mathematics of Dipoles and Loops

- 49/21/a An extensive purely mathematical consideration of all aspects of dipoles and loops. Manuscript (KM) Undated
- 49/21/b Determination of antenna reactance from the far field expressions. Tollios & Weber. IEEE Proceedings Letters 1973(?)
- 49/21/c Noise considerations in Active Monopoles. Tang & Gunn. Typed paper with no date or publication information, but bears a manuscript note at heading 'IEE Proc H 1986 Microwaves, Antennas & Propgn' and a further note 'MAP 892 24.8.86'

(49) (KM22) Tracking Servos

Collection of papers on Servos and associated systems

- 49/22/a Active compensation circuits for servo control systems. Wilson and Burl, Radio & Electronic Engineer Vol 43 No 6 June 1973
- 49/22/b Flicker Noise. KM manuscript notes and problems
- 49/22/c Notes on Phase Locked Loops. KM. 15.1.1980
- 49/22/d Noise Bandwidth of Type 2 Loop Servo System : Bandwidth : Dynamic Lag : Noise Jitter Response to wind gusts. Typed notes KM July 1984
- 49/22/e Wind loads on antenna systems. Brown & McKee, Microwave Journal, September 1964
- 49/22/f Calculation of sample loading see above (e) KM
- 49/22/g Graphical method of designing notch filters. Bell. Inst.Engineering, Australia. Vol 35 No 3 March 1962
- 49/22/h Effect of AGC on tracking accuracy of monopulse radar systems. Dunn & Howard, Proc IRE March 1959
- 49/22/i Indication of the vertical from moving bases. Wrigley, Houston & Whitman, IRE Trans of Aeronautical & Navigational Electronics
- 49/22/j Variation of angle sensitivity with signal/ noise ratio for tracking radars with linear detectors. Draft copy of RRE Memo 1551 (Alan Shaw)
- 49/22/k Effect of AGC on radar tracking noise. Delano and Pfeffer. Proc IRE June 1956
- 49/22/l Phase locked demodulator. KM MS notes 10 Nov 1967
- 49/22/m Tracking system for SkyNet 'V' (Unattributed but probably KM, see next item)
- 49/22/n Notes on Servo Bandwidth for Skynet 'V':
a) initial notes, b) Optimised Type 1 Servo, c) Optimised Type 2 Servo. KM Manuscript notes, undated. Draft of Paper or article/report KM 23.11.73 (?)
- 49/22/o Tracking rates for Alt/Azimuth Aerial Mounts for satellite tracking. Draft of Decca (HRL) HRL/419 Report 22.8.1961

(49) (KM23)

Copy of RRE Memorandum No 1551. An Analysis of variations of angle sensitivity with Signal/Noise Ratio for Monopulse Radars with Linear Detectors. A.H. Shaw & W. Phillipson (RRE) September 1962

See File 49 (KM22) item (j)

This final issue includes the results of measurements, not available at the time of the draft (above)

(49) (KM24)

- 49/24/a Target Echo characteristics with cylindrical wave illumination. K. Milne 1968. Interim report for Contract NCW 121/1115.
- 49/24/b (Loose insert) Single page copy of Daily Express, Jan 28 1984. Shows Advert for RAF Defence Radar Controllers, Technicians & Software Developers (Reverse side shows various adverts. for mainly technical staff)
- 49/24/c (Loose insert). Target Characteristics. Woolcock (EMI Electronics)
A wide ranging paper on the derivation of Radar Cross-sections of targets

(49) (KM25)

- 49/25/a Radar Equations for Jamming and Clutter. Barton. IEEE Trans. Aerospace and Electronic Systems Vol.AES3 No6 November 1952
- 49/25/b Detection Probability of slowly fading targets in a Frequency diversity System. KM Manuscript Notes, undated

(49) (KM26)

A series of papers by K. Milne et al re synthetic aperture radar, resolution of targets and clutter rejection, 1983 to 1984

Some are Company (various) classified, as at that time

- 49/26/a Aspects of synthetic aperture radars, clutter rejection and directional aerals. 16 Dec 1984
- 49/26/b Draft of 'Final Report' Jan 1985
- 49/26/c Initial System test. (KM) 1984
- 49/26/d Sea Surface Scatter. 'Encounter' working paper. June 1984
- 49/26/e Signal Processing KM May 1984
- 49/26/f Proposal for a 3 element airborne passive ranging interferometer. KM Feb 1984
- 49/26/g Basic principles in Hand sketch drawings and manuscript text (undated) in KM handwriting.
- 49/26/h In Envelope, Overhead projector sheets re (g) above
- 49/26/i Investigation into Beam Forming networks KM 1983 April
- 49/26/j Range accuracy of 'interferometric passive detection systems' KM October 1983

(49) (KM27)

49/27/a Theoretical analysis of transfer admittance of filter sections

49/27/b Theoretical analysis of compensated switched couplers

(49) (KM28)

49/28/a Note on Radar target discrimination (Typed) KM July 1990

49/28/b Handwritten theoretical calculations re (a) above

(49) (KM29)

- 49/29/a Manuscript theoretical note re 'Product of two independent processes', (undated) KM hand.
- 49/29/b Maritime Surveillance Radar. Part 1 Radar Scattering at Ocean Surface. Reprint of paper IEE Proceedings Vol 137 Pt F No 2 1990. Watts, Baker, Ward
- 49/29/c Maritime Surveillance Radar. Part 2 Detection performance prediction in Sea Clutter. References as (b) above
- 49/29/d Modelling spacially correlated K- Distributed Clutter. Note by Armstrong and Griffiths 10 Feb 1991 re (a) & (b) above
- 49/29/e Single Pulse CFAR Detection of fluctuating targets in a K-Distributed Sea Clutter. Note by Armstrong & Griffiths (Undated)
- 49/29/f Reprint. Generalised K-Distribution. A Statistical Model for weak scattering. Jakeman & Tough (RSRE) J Optical Soc of America September 1987
- 49/29/g Detection of a non-fluctuating Target in K-Distributed Clutter. (Note taken from RSRE Newsletter, Ward & Pusey. Undated but after 1978, see Ref b)

(49) (KM 30)

- 49/30/a Working Paper (KM2). Multipath over the Sea KM May 1986 (A Covering Letter 21 May 1986)
- 49/30/b Handwritten theoretical analysis Headed 6th Deficit Polynomial(?) Undated, in KM hand
- 49/30/c Letter from C.D. Bell (Admir. Res. Est. 6 Feb 1986 Greenwood (Scicon) covering enclosure, Program listing for testing of Multipath model
- 49/30/d Calculation of Field strengths over a Spherical Earth. Domb & Price. Reprint of Radio Section Paper 1947, Proc IEE Vol 94 Pt 3

(49) (KM31)

'AR3D': Radiated signals with Linear Frequ. Mod. inputs. Manuscript undated. In KM Hand.
(AR3D was a Plessey Private Venture 3 Dimension Radar, using frequency scan during pulse duration, to give elevation scan using a slotted waveguide for height determination)

(49) (KM32)

Reduction of Antenna Dimensions by Dielectric Loading. The results of measurements on various antenna. James Schuler and Binham. Electronics Letters 27 June 1974 Vol. 10 No 13 (Reprint)

(49) (KM33)

- 49/33/a Monopulse Comparator Design. Graham. Typed Note, no date
- 49/33/b Array Aperture Sampling for Multipath Compensation .. Willworth & Kupiec, Microwave Journal, June 1976. Reprint
- 49/33/c An Experimental Study of Monopulse Radar for Ground Clutter Discrimination. Chang & Stabilito. Conference Proceedings 4th National Convention on Military Electronics 1960. Reprint
- 49/33/d Optimum Aperture Distribution of a multimode Monopulse Horn feeding a Paraboloid of infinite Focal Length. Typed note, no attribution or date
- 49/33/e Optimum Illumination taper for 4-horn Monopulse aerial system. K. Milne & Raab. Typed note. No date
- 49/33/f Five Horn Tracking Feeds for Large Antennas. Sciambi. Reprint from proceedings of Large Steerable Aerial Conference, June 6-8 1966

(49) (KM34)

- 49/34/a Letter to Hargrave STL Ltd. (KM)
- 49/34/b Handwritten note re angle of arrival (of radio signal). Part (b) of item (a) above. No copy of Part (a)
- 49/34/c Spurious Sidelobes in Auxiliary antennas for 'Rapier'. Typed note (KM) dated May 1981
- 49/34/d Appendix to (c) above. Wide Angle Scanning Path-Length Lenses. Typed Note (KM) May 1981.
- 49/34/e Reduction of Tracking Errors induced by Multipath at Low Elevation Angles. Barton & Warddoup. Precopy of paper for Low Altitude Tracking Session at IEEE National Telecommunications Conference Dec 1980. (Houston, Texas)
- 49/34/f Digital Beam Forming for Radars. P. Barton. IEE Proc. Vol 127 PtF No4 Aug 1980 (Reprint)

(49) (KM35)

Approximate Polarisation Scattering Matrix for Monostatic Travelling Wave Echoes from flat Rectangular Plates .. Typed note (KM) Aug 1987

(49) (KM36)

Angular Errors. A very comprehensive overview of most (if not all) sources of error in determining the position of an airborne target. (KM) Feb 1989. With covering letter on sending copy to Mr Eggert of Scicon Ltd.

(49) (KM37)

- 49/37/a Millimetre Wave Radiometry. Morton, Newton & Gagliano. Copy of paper. SPIE Vol 337 Millimeter Wave Technology (1982/159)
- 49/37/b Multifrequency Millimeter Radar Sea Clutter Measurements. Trebits, Currie & Dyer. CH 1476 -1/79/0000 -0261500.75. 1979 IEEE
- 49/37/c Agenda for Colloquium on 'UK results from ATs/6 Millimeter wave Propagation Experiments' 10 Jan 1977 ..
- 49/37/d Copy of papers resulting from Colloquium above (c). IEE 10 Jan 1977 Professional Groups E9 (Sat.Coms.) and E11 (Radio Propn. and aerals)

(49) (KM38)

- 49/38/a Letter to Dr Brown of Easat Antennas Ltd 11 Sept 1995
- 49/38/b Letter from Dr Brown Easat Ant Ltd giving rise to (a) to KM 5 Sept 1995
- 49/38/c Notes on Antenna Sidelobe Specification. Aug 1995 and covering note (KM) Aug 1995
- 49/38/d Clutter Specification for Low Level Radars operating at 1 to 20 GHz. KM 1982
- 49/38/e Program associated with above (c)
- 49/38/f Transition Ranges for Targets over Sea Surface. Typed paper KM March 1989
- 49/38/g Typed paper on 'Rain Clutter' KM March 1990
- 49/38/h Easat Antennas Ltd Brochure on Aerials made and supplied by them

(49) (KM39)

- 49/39/a Direction Finding on spread spectrum signals using the time domain filtered cross spectral density. Houghton & Reeve Jan 1997. First draft. Publication source not identified.
- 49/39/b Typed comments (KM?) undated on (a) above
- 49/39/c Mathematical analysis of (a) above. (KM?) unsigned manuscript, undated
- 49/39/d Detection of spread spectrum signals using time domain filtered cross spectral density. Houghton & Reeve IEE Proc Radar, Sonar, Navign. Vol 142, No 6 1995. Published version of (a) above.
- 49/39/e The pdf & cdf for the sum of N Filtered outputs of an analogue cross correlator with bandpass inputs. Andrews & Price IEEE Transactions for Information Theory, Vol IT-29 No 2 March 1983 Reprint
- 49/39/f New Expression for the pdf & cdf of the filtered output of an analogue cross correlator, Brice & Andrews IEEE Transactions on Information Theory, Vol IT-28 No4 July 1982. Reprint
- 49/39/g Program Listing for Radar dir. Corrp Det
- 49/39/h Theoretical Performance of a complex crosscorrelator with Gaussian signals KM No date. Handwritten note, original version and program

(49) (KM40)

A note on antenna radiation patterns. KM July 1993

(49) (KM41)

Confusion Transmissions from Electronically scanned Arrays KM 25.5.1973.

Typed note (signed)

(49) (KM42)

49/42/a An Overlapped Sub Array for Limited Scan Applications. Mailloux 27 Sept 1973. Physical Sciences Research Papers No 566 Air Fares Cambridge Research Labs USAF AFCRL TR 73 0598 (Unclas)

49/42/b With handwritten note (KM)

(49) (KM43)

Travelling Wave Echoes from Flat Rectangular Plates KM Feb 1983 Typed notes

(49) (KM44)

- 49/44/a Notes on optimum Threshold for M/16 Counter Integration. KM Jan 1981
Typed Notes
- 49/44/b Appendices referring to a Swedish Specification (unspecified) unattributed
and undated. Sections relate to:
(a) Standoff Jamming
(b) Chaff
(c) Rain
(d) Sea Clutter
(e) Ground Clutter
(f) Archipelago (e) + (f)
(g) Angels
- 49/44/c 'Radar System Fundamentals. Lists of Radar Types and Main Characteristics.
Source not stated
- 49/44/d Trends in Modern Radar System Design 'Electro76' Professional Program
Boston May 11-14 1976 IEEE
- 49/44/e Radar Mortar Locator Development in the UK, The First 30 Years.
J.G. Milner. IEE Proceedings Vol 131 Part F No 2 April 1984

(49) (KM45) Ken Milne's Personal College Lecture Notebooks

49/45/a Mathematics DF1&2

49/45/b Mathematics DF3

49/45/c Electrical Machines & Transmission Lines

49/45/d Vectors

(49) (KM46) Copies of KM Personal Published Papers

- 49/46/a Theoretical Performance of a Complex Cross Correlator with Gaussian Signals IEE Proc Vol 140 No 1 Feb 1993
- 49/46/b Radar & Antennas Pt 1 Electronics & Communication Engin. J Nov/Dec 1989
- 49/46/c Ditto Pt 2 Feb 1990
- 49/46/d Planar Phase Shifting Structures For Steerable DBS Antennas With Griffiths & Vernon. Location unspecified
- 49/46/e Prediction of Sea Multipath Fading Characteristics
- 49/46/f Antenna Diversity in Digital Mobile Radio With Narhi, Laukkanen, Griffiths & Chapman. Proc Internat Conf on Digital Mobile Radio Coms. 30June-3July 1987
- 49/46/g Synthesis of Power Radiation Patterns for Linear Array Antennas IEE Proc Vol 134 Pt H No 3 June 1987
- 49/46/h Principles and Concepts of Multistatic Surveillance Radars. IEE Radar 1977 Conf. London 25-28 Oct 1977
- 49/46/i Plans & Developments for Air traffic Control Systems. Reprint from AGARD Conference Proc. No188
- 49/46/j Design & Operation of Skynet Type 5 Terminal. With Lawrence & White IEE Conf 1970 Earth Station Technology
- 49/46/k Naval Satellite Coms With G Harries
- 49/46/l Optimum Illumination Tapers for 4 Horn & 5 Horn Monopulse Aerial Systems With Raab. IEE Conf on Large Steerable Aerials June 1966
- 49/46/m Combination of Pulse Compression with Frequency Scanning for 3 Dimensional Radars. Synpos. On Signal Processing in Radar and Sonar Paper 5
- 49/46/n Channelling arrangements for a non-synchronous Satellite Coms System with Freedom of Access for a Number of Earth Stations. Int Conf on Satellite Coms 22/28 Nov 1962
- 49/46/o The Effects of Phase Errors on Simple Aperture Illuminations (KM at BTH Co) No date but possibly late 1940's or Early 50's when he was involved in Orange Yeoman and early Yellow River Aerial Design

(49) (KM47) Sundry Program Structures

49/47/a Flat Plate Echoing area

49/47/b Various Figures of Revolution:
(a) Disc
(b) Ellipse
(c) Ogive
(d) Parabola
(e) 'Travelling Wave Echo'
(f) Cylinder Various ratio sizes
(g) Cone Various Dimensions
(h) Disc Various Dimensions
(i) Ellipse Various Dimensions
(j) Paraboloid various dimensions

(49) (KM48)

- 49/48/a Offset parabolic reflector Antennas. A Review
- 49/48/b Recent advances in microwave reflector aerials. Prof. Clarricoats. Proc IEE
Vol 126 No 1 Jan 1979
- 49/48/c Reflector Synthesis for generalised far-fields. Westcott & Norris. J of Physics
A Maths Gen.Vol8 No4 1975
- 49/48/d Realisation of Generalised Far-Fields by reflector synthesis (part only).
Electronics Letters 25 July 1974 Vol 10 No 15
- 49/48/e Cross correlation in Wave Guide Feeds Claydon & Harris. Undated
- 49/48/f Power Conservation for reflector antennas with truncated feed patterns. Rusch
& Cramer. Undated
- 49/48/g Corner Reflector antenna with improved power gain. Morris, Maclean &
Bailey. Microwaves, Optics and Acoustics April 1977
- 49/48/h Handwritten KM Notes on various subjects, including:
 - a) Phase of radiation patterns of defocussed beams
 - b) Phase difference between 2 displaced defocussed beams
 - c) Defocussed antennas
 - d) Spherical Reflectors
 - e) Phase Centre of reflector aerial
 - f) Phase error in spherical reflector
 - g) Addition of beams from spherical reflectors
 - h) Design of 'Angle Scaling' reflector
 - i) Path length to aperture phase
 - j) Refraction at a spherical interface
 - k) Two separated lensesPLUS other topics
- 49/48/i The design of metal plate microwave lenses fed by non-resonant slotted
waveguide arrays. Crompton Monograph No 382E May 1960 IEE
- 49/48/j Use of dispersive artificial dielectrics in a beam scanning prism. Seeley &
Brown. IEE paper No 2735 1958
- 49/48/k Fields associated with an interface between free space and an artificial
dielectric. Brown & Seeley IEE monograph 300R April 1958
- 49/48/l Scanning aberrations of Radio Lenses Cheston & Shinn Marconi Review
undated Reprint

(49) (KM49)

- 49/49/a Manuscript notes on Partial Fractions in KM hand
- 49/49/b Computer program to evaluate Partial Fractions
- 49/49/c Manuscript notes on Entropy in KM hand
- 49/49/d The RF Spectrum of a carrier phase modulated by noise. Redmill. RAE
Technical Note No 71239 Dec 1971
- 49/49/e RF Spectra of waves frequency modulated with white noise. Medhurst. IEE
Monograph 380E May 1960
- 49/49/f Minimum spacing between orthoganol beams. Typed paper KM 4 Feb 1974
- 49/49/g Typed and with handwritten notes on Matrix Diagonalisation
- 49/49/h Handwritten notes on Entropy. KM hand
- 49/49/i Handwritten notes on 'solution of 2 Quartiles'. KM hand
- 49/49/j Handwritten note on solution of Quartiles. KM hand
- 49/49/k Computer program for solution of Quartiles
- 49/49/l Handwritten note on Cubic Equations with real coefficients. KM hand
- 49/49/m Computer Program for solution of Cubic Equations
- 49/49/n Handwritten notes on 'Lafrange' Interpolation Polynomials. KM hand
- 49/49/o Handwritten notes on Huygens Principle for Electromagnetic Waves
- 49/49/p Further considerations re (o) above

(49) (KM50) Notes on RADANT Antennae and prisms

Discussion of the disadvantages and problems as against the advantages of simpler controls and control systems

(49) (KM51) Propagation over the surface of Earth

- 49/51/a Colloquium on Urban Propagation IEE Electronics Div. Prof. Gr. 11 6 March 1978 Digest 1978/20
- 49/51/b Ground-wave propagation over an inhomogeneous smooth earth. G. Millington. IEE Radio Section 8 November 1948
- 49/51/c The Norton Surface Wave. G. Millington Marconi Rev Vol32 No175 4th qu 1969
- 49/51/d Calculation of Ground Wave Intensity over finitely conducting Spherical Earth. E.A. Norton Proc IRE Dec 1941
- 49/51/e Ground Wave Propagation Pt 1 Theory for short distances. S Rotheram. IEE Proc Vol 128 Pt F No5 October 1981
- 49/51/f As above (e) Pt 2 Theory for med and long distances, with Reference Curves
- 49/51/g Propagation of radio waves over surface of earth and in upper atmosphere. K.A. Norton Part1 Ground wave propn. From short antenna. Proc IRE Vol 24 No 10 Oct 1936

(49) (KM52) Propagation over sea

- 49/52/a Low angle reflection at 5GHz. E.J. Guiver RAE Tech Rpt. 80146, Nov 1980
- 49/52/b Directional Sea Spectrum using HF Doppler techniques. Dennis B Trizna, J C Moor, J M Hedrick, R W Bogle. Trans. IEEE Trans on Antenna and propagn. Vol AP 25 No1 Jan 1977
- 49/52/c New derivation for Rough Surface Reflection Coeff. for Distn. of Sea Wave Elevations. A.R. Miller, R.M. Brown & E. Vegh. IEE Proc.Vol. 131 April 1984
- 49/52/d Extraction of Sea-state infn. from Radar Doppler Spectra. Lucy Wyatt. Colloquium on Sea Surface 1979/9
- 49/52/e Short pulse radar used to measure Sea Surface wind speed and SWH. D.L. Hammond, R.A. Mennella, E.J. Walsh. IEEE Trans. (Antenna & Propagn. Vol. AP25 No 1. Jan 1977
- 49/52/f Theory of HF & VHF propagn across rough sea. 1. Effective surface impedance for a slightly rough highly conducting medium at grazing incidence. D.E. Barrick. Radio Science Vol6 No 5 P517-526 May 1975
- 49/52/g As above (f) Pt 2 Application to HF & VHF Propagation above the Sea

(49) (KM53) Radar Clutter

- 49/53/a Radar Clutter & Multi path Propagation. IEE Special Issue , 'Radar and Signal Processing Vol 138 No 2 April 1991. Various Authors. 13 articles listed on back cover
- 49/53/b Specifications for clutter, attenuation & propagation for assessment of Wpn. systems & sensors. Prepared by R.G. Taylor DRA Portsdown (Unclass.)
- 49/53/c Simulation of non-uniform clutter. R.J. Miller GEC Research 1987
- 49/53/d Brief Resume of problems with Sea Clutter, using High Resolution I-Band Radar. T.J. Hurley Marconi Co Ltd Naval Div. ST/282/TJH /2396 5 Nov 1987
- 49/53/e A New Model for Sea Clutter. J.W. Wright. IEEE Trans.(Ant & Propn)Vol AP 16 No 2 March 1968
- 49/53/f Microwave scattering from Sea Surface. K.B. Ward & C.J. Baker. RSRE. undated
- 49/53/g Handwritten notes by KM on Capillary waves
- 49/53/h Nature of Backscattering from Water waves. D.S.W. Kwok & B.M. Lake. TRW Space and Technology Group Redondo Beach California. (Typed)
- 49/53/i Coherent & Incoherent Scattering of Microwaves from the Ocean. C.L. Beard. IRE Trans. (Anten & Propn.) Sept 1961.
- 49/53/j Radar Detection prediction in non-Rayleigh Sea Clutter. A collection of notes from several sources. No attribution other than from: Admiralty Research Establishment, Portsdown
- 49/53/k Simulation of Non Uniform Clutter R.J. Miller GEC Research 1987 (Typed)
- 49/53/l Analysis of High Range Resolution Reflections (Final Report) D.E. Wright, T. Hair, D. Shepherd, T. Lee MTR 87/128 December 1987

(49) (KM54) Multi-path Reflections

- 49/54/a Some measurements of X-band interference patterns at low altitudes over Sea. I.M. Hunter, L.H. Phillpotts & T.B.A. Senior RRE Technical Note 581 Oct 1959 (Unclassified)
- 49/54/b Clutter and Common TR problems using high power Computer Controlled Coherent Radar. B.B. Davy, C.S.F. Phillips. RRE Memorandum 2349, May 1968 (Unclassified)
- 49/54/c The Maxima and Minima in the field of an aerial above a spherical earth. T.B.A. Senior. RRE Memorandum 1198 Oct 1959 (Unclassified)

(49) (KM55) Cross Correlation

Theoretical Performance of a complex Cross-Correlator with Gaussian signals. K.Milne. IEE Proc. F Vol 140 No 1 Feb 1993

(49) (KM56) mm Beam forming and allied mm matters

49/56/a Beam-forming techniques for Passive mm Wave Imaging Draft Final Report. H.D. Griffiths, K. Milne, A.J. Seeds. UCL (for Thomson, Thorn Missile Electronics Ltd June 1998

49/56/b The Wavelet Theorem Glen Davidson Feb 23 1998

49/56/c Appendix A to (a) above in the form of a lecture with OHP sheets. Mm wave Radiometers. No attribution. In envelope

49/56/d Beam Forming Techniques for Passive mm Wave Imaging Sect 3. OptoElectronic Beam Forming Systems. A.J. S

49/56/e Note on effective S/N ratio in Correlation Arrays

49/56/f Mechanical Scanning of Multibeam Radiometers. No attribution

(49) (KM57) NATO Tech. Rpt. TR 50 U (April 1969)

Standard Methods for predicting and specifying performance of Air Surveillance Radar Systems. By J.A. Bijvoet, NATO Systems Research Div, SHAPE Tech. Centre. April 1969
(Unclassified)

(49) (KM58)

Hand calculations re Flicker Noise in Resistors and other components. Manuscript

(49) (KM59)

Tracking Control in Multi-function Radars

A Thesis by J.M. Butler for transfer from M.Phil to Ph.D, March 1998, Dept of Electronic and Electrical Engineering, UCL

- (49) (KM60) Tracking Algorithms. A series of papers from different sources concerned with Radar Tracking Accuracy
- 49/60/a KM Note on Tracking Philosophy Nov 1981
- 49/60/b Automatic Tracking. The Occam Filter. J.E. Holmes, ASWE Working paper Oct. 1975
- 49/60/c Technical Introduction to the OCCAM Filter, Plessey RSL 1703 Sept 1975
- 49/60/d A Geometrical approach to problems with errors in variables. Paper by Soh, R.J. Evans and F. Barker, (Origin, Australia). Also KM Calculations in explanation of the report
- 49/60/e A Least Area Resolution of Ambiguities in Least Square Estimators. F. Barker & R.J. Evans Nov 1984 Newcastle Univ NSW
- 49/60/f KM Manuscript Calculations and Comments (for further investigation)
- 49/60/g The Development of Algorithms for the Formation and Updating of Tracks. Quigley & Holmes ASWE WP XBC 7512. November 1975
- 49/60/h Letter and calculations re a query from KM to D.E. Piper re digital polynomial method, 11 Sept 1974

Loose Papers

- 49/60/i A new approach to Linear Filtering and Prediction problems. R.E. Kalman J. Basic Engineering March 1960
- 49/60/j Tracking and Smoothing. Morrison (Chapter 25) Raytheon
- 49/60/k The Kalman Filter. Sheats. (Chapter 26) Raytheon

(49) (KM61) Ground Clutter & Associated Radar Phenomena

- 49/61/a The Overall Probability Distribution of Ground Clutter for Ground-based Surveillance Radars. E.J. Dodsworth, RSRE Memorandum 3066, April 1977 (Unclassified)
- 49/61/b Flat and Rolling Terrain Clutter Model, D.K. Barton DKB: 82 10 Marconi Research Centre
- 49/61/c Combined MIT & Cranwell Biblio. Clutter & low Level Tracking Bibliography Twenty Eight pages of Report References
- 49/61/d Studies of Temporal Thresholding in High Resolution Ground Clutter. R.J. Miller MTR83/9 Jan 1983
- 49/61/e The Nature of Microwave Backscattering from Water Waves. D.S. Kwoh and S.M. Lake. TRW Space & Technology Gr. Cal.
- 49/61/f Image Reconstruction by Maximum Entropy. Kemp & Skilling, Cambridge UK
- 49/61/g Inverse Scattering by Electromagnetic and Allied Methods. IEE Colloquium Oct 1982 Digest No 1982/68
- 49/61/h Models of SAR Sea Imaging. S. Rotherham Marconi Res Centre
- 49/61/i Harbor Surveillance Radar Detection Performance. D.C. Schleher IEEE J. Oceanic Engineering Vol OE2 No 4 Oct 1977
- 49/61/j Ship Motion Measurement Filter Design. I. Weiss & T.W. Davies IEEE J Oceanic Engineering Vol OE2 No 4 Oct 1977
- 49/61/k Some Recent Observations of Sea Spikes. B.L. Lewis & I.D. Olis. Radar Div Naval Res Labs Washington DC
- 49/61/l A Model for Backscatter Intermittency at Extreme Grazing Angles. L.B. Wettel Radio Science Vol 12 P749-756 Sept-Oct 1977 Naval Res Labs Washington
- 49/61/m Colloquium on The Seas Surface, Target or Clutter IEE Prof G.r.El5 Radar, Sonar & Navigation Systems Digest 1979/9 12 Feb '78
- 49/61/n The Effect of Pulse Length changes on Weibull Clutter. J. Clarke & R.S. Peters RRE Memo 3033 Nov 1976 Unclassified
- 49/61/o Memo from K.M. to staff, re Weibull Distribution, July 1976

(49) (KM62) Detection Statistics

- 49/62/a Manuscript calculations; Rayleigh Considerations & various consequences
- 49/62/b Integrated output of a cross correlator fed with Gaussian noise
KM. Aug. 1991 (Typed)
- 49/62/c Complementary Pairs(?) of Sequence Manuscript calculations
- 49/62/d Sum of(?) Manuscript calculations
- 49/62/e Sums of Reciprocal Powers Manuscript calculations
- 49/62/f Adaptive thresholding. Colloquium Prod Gr.E15 and Prof Gr.8.....
March 25 1981 Digest 1981/24
- 49/62/g The Probability Density Function for the Output of a Cross Correlator with
Bandpass Characteristics. L.C. Andrews, IEEE Transactions on information
theory
- 49/62/h Trends in Radar Signal Processing and System Supplementary Notes -
Automatic Detection. Dr I. White. Bosworth Course in Radio
Telecommunications and Radar Technology
- 49/62/i Evaluation of Infinite Integrals by Contour Integration. Manuscript
calculations

(49) (KM63) Null Steering and Adaptive Arrays

- 49/63/a Deep Null Steering by Controlling Element Excitation Phase. Hu Jin Ling & Lin Shi Ming, 6 Feb 1996. 101 Institute North Western Politechnical University 710072 Xi' an P.P.R. China
- 49/63/b Generalised Array Pattern Synthesis Using the Projection Matrix Tung Sang Ng, Dept of Electrical & Computer Engineering, Woollongong NSW Australia
- 49/63/c The Adaptive Array with Tailored Robustness, J. E. Hudson
- 49/63/d Adaptive Arrays. S.F. Applebaum. IEEE Trans. on Antennae & Propagation Vol AP24 No5 Sept 1976
- 49/63/e Cascade Preprocessors for Adaptive Arrays. W.D. White. IEEE Trans on Anten. & Propagation Vol. AN24 No 5 Sept 1976
- 49/63/f Adaptive Beam Weighting. J. Gobert IEEE Trans. Anten. & Propagation. Sept 1976
- 49/63/g Effects of Element Crosspolarisation in Adaptive Antennas. A.K. Brown, STL & Univ of Surrey
- 49/63/h Adaptive Arrays, a Theoretical Introduction. M.D. Windram. IEE Proc.Vol. 127. Pt. F. No 4. 1980
- 49/63/i Adaptive Arrays with Main Beam Constraints. S.P. Applebaum & E.A. Chapman. IEEE Trans on Anten. & Propagation. Vol. AP24,No.5 Nov 1976
- 49/63/j Comparison of Adaptive Algorithms Based on the Methods of Steepest Descent and Random Search. B. Widrow & J. McCool. IEEE Transactions on Anten. & Propagation Vol AP24 No 5 Sept 1976
- 49/63/k The Orthomode Transducer. (Non-Attributed)
- 49/63/l Adaptive Beam Forming Using Cascade Configuration. R.K. Hanna & B.B. Madan (and comments by D.E.N. Davies 26 Nov 1981)
- 49/63/m Adaptive Cascade Networks for Deep Nulling. W.A. White IEEE Trans for Anten. & Propagation Vol AP26 No.2 April1978
- 49/63/n Adaptive Arrays, an introduction W.F. Gabriel. Proc IEEE Vol 64 No 2 Feb 1976
- 49/63/o Adaptive Arrays for Source Parameter Estimation. Electronic Letters 25 Nov 1976 1978 Vol 12 No 24
- 49/63/p Range Measurements from Random Array phase Measurements S.A. Kassam & Y Shammash Univ Pennsylvania
- 49/63/q Adaptive Arrays IEE Colloquium 24 March1977 Digest 1977/21
- 49/63/r Steering of Zeros in the Directional Pattern of a Linear array
- 49/63/s Zero Steering of the Directional Pattern of a Linear Array in the Presence of Mutual Coupling. M. Mellors, D.E.N. Davies, Prof M.J. Withers. Proc IEE Vol 117 No1 Jan. 1970

(49) (KM64) Strip Scattering; Half Range Fourier Series (HRFS)

A series of Mathematical 'Essays' by KM, with supporting articles

49/64/a	(Labelled 'Important' in Red) F. T's of Semi Infinite Illumination Strip Lines
49/64/b	Strip HRFS
49/64/c	Strip TMTE
49/64/d	StripRotTM
49/64/e	StripEITM
49/64/f	StripTrTE

(49) (KM65) Miscellaneous

- (1) Polynomial Approach to Study of Single Ring Circular Antenna Array. A.Gerin. Proc IEE Vol 121 No 4 April 1974
- (2) Wave Reactance of Thin Planar Strip Gratings. M.J.Archer. Electronics Vol.58 No 2
- (3) Improved CFAR Detection in Spatially Correlated K-Distributed Clutter. B.C. Armstrong & H.D. Griffiths, Dept Electronic & Electrical Engineering UCL
- (4) Phased Array Theory & Technology. R.J. Mailloux Proc IEEE Vol 70 No 3 March 1982
- (5) Mode-Space Spatial Estimation for Circular Arrays. R. Eiges & H.D. Griffiths. IEE Proc Radar & Sonar Navig. Vol 141 No 6 Dec. 1994
- (6) Synthesis of Power Radiation Patterns for Linear Array Antennas. K. Milne. IEE Proc. Vol 134 Pt H. No3. June 1987
- (7) Standard Distribution (2) Ch.8 from Vol.1 The Advanced Theory of Statistics (book) by H.G. Kendall 1947
- (8) The Use of an Active Phased array in SAR Applications to Reduce Speckle. Unattributed Manuscript. Undated.
- (9) A Null steering system for Low Cost, low G/T Maritime Mobile Satellite Coms. Earth Stations. A.R. Brown, K. Milne, P.R. Foster. Racal
- (10) Gaussian Illumination. K. Milne. Manuscript Essay. Undated
- (11) Correspondence K.M. & Dr Knight & Paper, Synthesising the Radiation Pattern of a Ring Aerial. P. Knight. Industrial Electronics, July 1963
- (12) High T Superconducting Short Dipole Antenna. Electronic Letters, 14. 4 1988 Vol 24 No8. S.K. Khamas, M.J. Mehler, T.S.M. Maclean, C.E. Gough, N. McN. Alford & M.A. Harmer
- (13) Approximate Asymptotic Solution of a Surface Field due to a Magnetic Dipole on a Cylinder. Shung-Wu Lee & Safieddin Safavi-Naina. IEEE Trans. Antennas & Propagn
- (14) Emerging Technology for Transient & Broad-band Analysis and Synthesis of Antennas & Scatterers. Proc IEEE Vol 64 No.11 Nov 1976
- (15) Diffraction of a Plane Wave at a Finite Set of Cylindrical Conductors: Application to an electronic Scanning Antenna. Yves Michel, R. Pauchard, P. Vidal. Radant. Societe d'Etude du Radant
- (16) Millimetre Wave Characteristics of Phase Correcting Fresnel Zone Plates. D.N. Black & J.C. Wiltse. IEEE Trans. on Microwave Theory & Techniques Vol MTT 35 No 12 Dec 1987

(49) (KM66) Correspondence re Thesis and draft Book Chapters

- (1) Correspondence KM and WooKyung. UCL
- (2) Draft Chapter 6 of book (unspecified) for review by KM. 'Modified Matched Filter for an Optimal Uniform Sidelobe'
- (3) As (2) above, Chapter 7 'Integrated Side-Lobe Reduction'
- (4) Some notes on Polyphase Pulse Compression. Generating Optimal Uniform Sidelobes
- (5) Asymmetric Pulse Compression Waveform Design for spaceborne Meteorological Radars. M.D. Griffiths, L. Vinagre & K. Milne, UCL
- (6) Constant Amplitude, Non Linear FM. Paper by KM June 1966
- (7) A considerable series of Calculations, unspecified
- (8) A Note on Linear FM Chirp
- (9) Reducing Time Sidelobes on one side of the Response
- (10) Modern SAW-Based Pulse Compression Systems for Radar Applications. Part 2 Practical Systems. J.W. Arthur. Electronics and Communication Engineering J. April 1996
- (11) See (10) above Part 1

(490 (KM67) Synthetic Wave Pattern

Early radars radiated using projection shaping by physical contours such as paraboloids, semi cylinders and the like. Others used the combination of wave fronts to add or subtract phases and to produce interference patterns. In the 1950s onwards this latter method was considerably enhanced by deliberately shaping the phases and amplitudes of sections of a wavefront. This became the norm by the 1990s and became known as 'Synthesising the wavefront' and 'Phased Arrays'. This file consists of papers describing various Synthesis means.

- 1) Modal analysis of periodic planar phased arrays of apertures. G. V. Borgiotti. Proc IEEE Vol 56 No 11 Nov 1968
- 2) A novel expression for the mutual admittance of planar radiating elements. G.V. Borgiotti. IEEE Trans on antennas & propagation vol AP16 No 3 May 1968
- 3) Solution of slot admittance on a cone or cylinder. Lee, Young, Mittra. Proc IEE Vol 126 No 6 June 1979
- 4) Analysis and element pattern design of periodic arrays of circular apertures on conducting cylinders. G.V. Borgiotti. IEEE Trans of Antennas and propagation Vol AP20 No5 Sept 1972
- 5) Mutual admittance of slots on a cone. Solution by ray technique.
- 6) Optimising the synthesis of shaped beam antenna patterns. Orchard, Elliott & Stem IEE Proc Vol 132 Pt H No1 Feb1985
- 7) Synthesis of power radiation patterns for linear array antennas. K. Milne. IEE Proc Vol 134 Pt H No3 June 1987
- 8) Array Synthesis with excitation constraints. Franceschetti, Mazzarella & Panariello. IEE Proc Vol 135 Pt H No6 Dec 1988
- 9) The Analysis of circular waveguide phased arrays. Amitay & Galindo. Bell System Technical Journal 1968
- 10) Optimum design of a Gregorian-corrected spherical-reflector antenna. Phillips & Clarricoates. Proc IEE Vol 117 No4 April 1970

(49) (KM68)

One folder with specialist proposals for aerial

- 1) Number of beam positions for an idealised planar array. K. Milne. Nov 1997
- 2) Antenna Unit feasibility study for the Alcatel residential outdoor terminal (SOT). Brennan & K. Milne UCL Sept 1997
- 3) Correspondence Brennan-Milne Sept 1997 and enclosure of Alcatel Skybridge system, antenna feasibility study

(49) (KM69)

Study by KM. Undated, but latest reference is dated October 1987

1) Phased arrays in RADAR

(49) (KM70) Phased array antennas

- 1) Manuscript calculations (KM undated) on Frequency sensitivity of linear arrays
- 2) NATO Research Study Group on techniques for advanced surface based radars for SAM systems. Sept 1978
- 3) Microwave theory of phased array antennas: A Review. Stark. Proc IEEE Vol 62 No12. Dec 1974

(49) (KM71)

- 1) Effect of Deviation from ideal paraboloid shape of large antenna reflectors. Welsted, Microwave Lab, Danish Academy of Technical Sciences May 1966
Presented at Conference on design and construction of large steerable aerials, London June 1966
- 2) Comments and correspondence, K Milne --Welsted March 1973.

(49) (KM72)

- 1) Optimum patterns for endfire arrays. DuHamel. Proc IRE May 1953
- 2) Derivation of excitation coefficients for Tschhebyshev arrays. Drane. Proc IEE
Vol 110 No 10 October 1963
- 3) Excitation coefficients and beamwidths of Tschhebyscheff arrays. Stegen. Proc IRE
Nov. 1953
- 4) Dolph-Tschhebyshev Excitation coefficient approximation. Drake Air Force
Cambridge R.L. Bedford Mass. May 1964 IEEE Trans on Antennas & Propagation
November (1964)
- 5) Computations and manuscript derivations with graphs related to above (K. Milne)

(49) (KM73) A series of unconnected papers on subjects close to radar

- 1) Pseudo noise Sequences for engineers. Mutagi Electronics and Communications Engineering Journal April 1996
- 2) Notes on Eigenvector beams
- 3) A consistently rapid algorithm for solving polynomial equations. Moore. J. Inst Maths Applications 1976 17(99-110)
- 4) K.M. notes on Capacitive Strip Grid-Scanning in E plane
- 5) Technical paper (KM ?) Scientific and technological problems in undersea warfare

(49) (KM74) Tracking, errors and associated topics

- 1) Multi path tracking errors in elevation scanning and monopulse radars. Smith & Mrstik. Trans. on Aerospace & Electronic Systems, Vol AES 15, No6 Nov 1979
- 2) Characteristics of clutter and targets at X band and Ku band. Sittrop Phys Res Lab The Hague undated but last reference dated 1975
- 3) Radar cross-section of large structures with complex microgeometry. Williams. IEE Proc Vol 137 Pt F No4 Aug 1990
- 4) Short wavelength target modelling. Fante. IEEE trans. on Anten. & Propag. Vol AP32 No1 Jan 1984

(49) (KM75) A collection of papers and KM observations and calculations mainly based on probability

- 1) Detection probability by summing infinite series (unattributed)
- 2) Problems solved and unsolved in radar detection theory. Smith, Marconi 1977
- 3) Autoregressive processes. Box & Jenkins
- 4) Calculation of detection probability with intermittent jamming. Milne, July 1987
- 5) Notes on detection probability. Milne, May 1987

(49) (KM76) Number manipulation

- 1) Winograd's algorithm applied to number-theoretic transforms. Bailey. Electronics Letters Vol 13 No18 1 September 1977
- 2) Loose papers. KM Calculations re (1) above
- 3) Digital Signal Processing Pt 1 Digital filters and the DFT. Grant. Electronics and Communications Engineering Journal Feb 1993
- 4) D.S.P. (See 3 above) pt 2. Spectral Analysis. Grant & MacDonald. Electronics & Communications Engineering Journal August 1993
- 5) A review of the discrete Fourier Transform. Pt 1 (No later parts in KM Files). Manipulating the power of 2
- 6) Announcement of a meeting to consider a paper (attached): 'There is something much faster than the fast Fourier Transform.' To be held Oct 21 1976

(49) (KM77)

1) Low angle tracking radar. Barton. Trans IEEE Vol 62 No 6 June 1974

A relatively modem look at a problem noted on the earliest radars CH in UK in around 1937/8, severe on 15 metres, and of greater importance as the wavelengths decreased towards 3cm in 1943, when close surveillance over sea surfaces was paramount

(49) (KM78) Signal Processing

- 1) Wavelet transforms: an introduction. Bentley & Macdonald. Electronics & Communication Engineering Journal Aug 1994
- 2) Hadamand transform, image scanning. Decker. Applied Optics Vol 9 No 6 June 1970
- 3) Appendix. Transform Image Coding for Montana (L) White 1974
- 4) Addendum to (3) above, KM manuscript. Undated
- 5) Modem Data Encryption. Boyd. Electronics and Communication engineering Journal Oct 1993
- 6) Loose paper, part of a larger article. 'Arithmetic Circuits'. Application of semiconductors in logic number circuits (1992 Exam Question!)

(49) (KM79) A modem look at early radio circuits (1922?) and at radar circuits (1937/9?)

- 1) Sensitivity of crystal video receivers with RF preamplifiers. Klipper. The Microwave Journal 1965
- 2) Direct video detection with wideband amplification. Edward. IEE Proc Vol 129 Pt F No3 June 1982

(49) (KM80) Antenna interactions. Loose papers in file

- 1) Mutual coupling between antennas for emission or reception application to passive and active dipoles. J-P Daniel. IEEE Trans on antennas and propagation March 1979
- 2) Mutual coupling between antennas ... optimisation of transistor parameters for active antenna design. J-P Daniel & Terrey. IEEE Trans on Antennas & Propagation July 1975
- 3) Reduction of mutual coupling between active monopoles. Application to super directive receiving arrays. J-P Daniel. IEEE Trans on antennas & propagation Vol AP25 No6 Nov 1977
- 4) FD-TD Analysis of Vivaldi Flared Horn Antennas & Arrays. Thiele & Taflove. IEEE Trans on Ant. & Propag. Vol 42 No 5 May 1994
- 5) Analysis of tapered slot antenna. Janaswamy & Schaubert. IEEE Trans. on ant. & propag. Vol AP35 No 9 Sept 1987
- 6) Analysis of the transverse electromagnetic mode linearly tapered slot antenna. Janaswamy, Schaubert & Pozar. Radio Science Vol 21 No 5 Oct 1986.
- 7) Characteristic impedance of a wide slotline on low permeability substrates. Janaswamy & Schaubert. IEEE Trans. on microwave theory & techniques. Vol MTT34 No8 Aug 1986. Papers bound into folder
- 8) Notes on dispersal of grating lobes in arrays. K. Milne Aug 1995. No indication of publication
- 9) Preliminary note on array configurations. K. Milne July 1994. No indication of publication
- 10) Wideband dual polarised apertures utilising closely spaced printed circuit flared slot antenna elements for active transmit and receive phased array demonstrations. Povinelli G E Aerospace N.Y. Jour. of Electronic Defence Sept 1993
- 11) Proposal (Electronica UK Ltd, & UCL), March 1994, for collaborative study of Crosseye, RGPO, False target generation and counter ASM acquisition and homing and area protection, can be implemented using solid state technology
- 12) A linear and planar array simulation program for a Macintosh PC. Moss & Griffiths UCL

(49) (KM81) Secondary Radar

- 1) Siemens IFF Interrogator MRS 400 for AA Defence systems of small or medium range. Date (?) 30.06.72. See (2) below
- 2) Siemens IFF Transponder STR 700 Dated 30.0 6.72
- 3) Secondary Surveillance radar: Design of transmitters for airborne transponders. Conibear (Plessey) Print source not indicated
- 4 Secondary surveillance radar, design of transmitters for interrogators and transponders. Conibear (Plessey) Print source not indicated

(50) 'Wurzburg' Radar

A detailed description of the German 50cm radar, written by Arthur O. Bauer. In German

See also File 48 (EKW22)

(51) GL3. B.T.H.: Minutes of Development Meetings 1941 to 1943. 'Dr Warren's File'

B.T.H. became involved in the Development and Production of GL3 for the British Army, as a result of Rugby, their home, being close to Birmingham, and that they had assisted Prof. Oliphant and his team in the Birmingham University Physics Dept, in their making of centimetric transmitting valves, notably the Klystron which Oliphant had refined following the disclosure of the technique in 1938 by the Varian Brothers in the USA. BTH did not have any immediate connection with the Birmingham Magnetron development, but were quickly drawn in when it became obvious that the low power device (10 to 100 Kw) would satisfy the RAF Aircraft Interception role, and there was no incentive for GEC, the chosen manufacturers of the Magnetron, to exploit higher power valves, whereas the GL3 was assumed to require a pulse power of at least 250 Kw.

BTH were brought into the centimetric valve story in July 1940 at a meeting of the Special Valve Subcommittee and were instructed to develop the GL3 in October 1940. These are the minutes of the definitive Development Meetings, up to the time that the finalised design was in full production.

These are copies of the original minutes (originals are on very flimsy foolscap paper), but these originals along with a copy as this present deposit, have been placed in Birmingham University Library Archives, this being fitting since they involve original Birmingham University material and people. The Deposit at Birmingham is registered as: 1997/12, and its deposit date is 14 April 1997. The Receipt for the Files is at the front of the File.

The File was the personal Office File of Dr. Warren who was the Head of Research in the BTH Research Laboratory at Rugby. When he retired, the file was handed to Mr William Melville, one of his senior researchers, who had made a hobby of collecting Radar History, for safe keeping. He in turn first lent it to DHT, to peruse and copy as necessary at a time when DHT was lecturing on Army Wartime Radar, after which it returned to Melville. When he in turn after he retired and was seriously ill, returned them to DHT to deposit in a 'Safe Haven'. Hence the deposit at Birmingham.

This File is of considerable importance, because the GL3 Contract was the first one placed with a Manufacturer to develop a full Centimetric radar. There were slightly earlier contracts for AI equipment, but only for parts of the system, the development of the 10 cm parts being retained by TRE. In another later File, there will be a fuller description of the Development (See also the 'Paterson Papers' File. (File 52))

It is of interest that when BTH were given the contract in October 1940, they had no prior knowledge or expertise in short wave radio of any sort: the engineers had to learn a totally new technique, but they had produced the first experimental model sufficiently far by the end of March 1941 for it to be producing signals, and the model was completed, had undergone local test trials and was ready to ship to ADRDE at Christchurch on May 31 1941 for extensive trials.

Terminology:

B.T.H. = British Thomson Houston Company

G.E.C. = General Electric Company

GL = (anti aircraft) Gun Laying

ADRDE = Air Defence Research and Development Establishment

(52) Paterson Papers

Dr. Paterson was the Head of Research at the GEC Research Laboratories at Wembley. One of the main interests of the Research Laboratory was the development of all types of radio valves, concentrating especially in large high power transmitting valves. They supplied many Broadcasting Organisations including the BBC. They were to the fore on developing short wave transmitting valves and worked in close association with the Admiralty Valve Design Section of the Admiralty Signal School, much later to become the independent Services Electronic Research Laboratory at Baldock, which researched all thermionic valve matters for all three Services. GEC therefore were approached to manufacture the new Cavity Magnetron in July 1940, after Birmingham University had proved their design. They first of all produced sealed off valves, and then converted the design to air cooling in place of the original water cooling used at Birmingham.

GEC were involved in a number of other Radar projects at Wembley.

This file draws together the papers of Dr Paterson, in groups of allied interest. The original file was assembled in date order, and this obscured a clear view of the different subjects.

- 52/a Valve Development. Contains papers relating to BTH coming in to Magnetron Development and production (in which by 1943, they were the prime manufacturers of the higher power valves, having developed mass production methods of an advanced nature, (based in a new factory in Sunderland). It contains several references to the early testing of A.I.S, and the ongoing conflict at GEC between the desire for protection of their ideas and interests and the wider dissemination of war time information to allied partners.
- 52/b Valves and equipment for purposes other than magnetron related systems. This file is a mixed bag, but contains correspondence relating to spare and replacement BBC high power transmitting valves. These were used in both the normal radio transmitters, and in the special high power transmitters operated by the BBC, but disseminating war propaganda over Europe. The high usage of the high power valves caused considerable embarrassment to GEC in that it disrupted the normal supply of spares. The reason is not touched on, but in order to obtain the highest possible power output, the valves were totally overstretched by operating at 50 to 100% over voltage, but producing some 100 to 150% more power. This also producing short life. The file contains several references to war equipment design and production in addition to valves.
- 52/c A file on Administration, in which the concerns of the Board are shown, about the conflict between GEC's interests and those of maximum cooperation with the War effort, and also the dislike of the looser financial control necessitated by the war.
- 52/d 1944/45 papers. As the war neared its end, the desire to be compensated for their war effort came to the fore.

This file, now in 4 parts, was originally in one date order file, and it was difficult to follow the individual threads. It was the Office copy of Paterson's correspondence, and when he retired, he passed it to his friend, Dr Bill Eastwood, at that time the Director of Radar Research and Production at Marconi Radar in Chelmsford. He was sorely afraid that it would be 'lost' or destroyed if he sent it to the GEC Archives, a fear well founded, when later the GEC Archive was declared unnecessary to every day modern research, and was totally destroyed. Eastwood in turn passed the file to Bruce Neall at Marconi, the Radar Historian in the company. In order to ensure that documents were not lost, he made a complete copy for

DHT, whilst retaining the original. After retirement, when Bruce died, we tried to locate the original file, but it seems to have been thrown away, whereas Bruce had desired it to go to the IEE Archives.

(53) GL3 Monitor Van

The GL3 (AA No3 Mk2) was the first 10 cm Anti-Aircraft Radar produced in UK. It brought with it many totally new concepts of radio to the Army, and although there was a very good training system for both Technical Maintenance and Operational staff, there were severe shortcomings in the Field, often caused by over cautious approach to the equipment. As Designers, the GL3 Team at ADRDE, Malvern, were constantly being called out to go and locate faults which the regular Maintenance personnel could not locate. Most of these in fact did not exist, the problems often being simple ones of lack of setting up according to maintenance schedules, failure to complete original siting requirements, failure to connect power cables correctly to Diesel Generators, or failure to recognise that a fuse had blown, often when an incorrectly rated fuse had been put in a power circuit. (DHT was requested twice in one week to go to sites, one in Birmingham and one in Leeds, because part of the display console would not work! In both cases, a power switch had not been switched on ... On another occasion, a fuse had blown, and the technician reported that every time he put a new fuse in, it blew on switching on. In this case a locking pin which prevented a mercury switch from rocking when the equipment was travelling, had not been removed during site setting up).

This led to DHT putting forward the idea that a specialist Army (REME) team be set up, specially trained not only at ADRDE, but also at the two equipment manufacturers BTH at Rugby and Leicester, and EMI (The Gramophone Co. at Hayes, so that they really understood everything that could be known about the equipment. They were to be provided with a 3 ton cabin lorry, fitted out with every possible type of Test Gear that they might require. They would go around AA Radar sites both according to a schedule or at times unannounced, and would carry an authority to do so. (In the event, it was signed by Gen. Pile). Fortunately the relevant Army Branch (ME8) were enthusiastic and the next six months saw a frantic building and calibration of special equipment, and training of a REME captain, sergeant and corporal as well as a driver, who was trained to do other essential tasks such as filling a balloon with hydrogen to carry a radar reflector aloft (saving having to fly aircraft). The Captain was also given special training so that he could devise special equipment or facilities in the field, as required. He always had direct access to the ADRDE Designers, but generally would have to be self-sufficient.

When the team got out into the field, they were soon in great demand as news spread from site to site and they (gently) showed the staff how to coax that bit or lot, extra, as the case might be from the equipment. The Army then decided that it was essential that the Unit went to France with the Invasion, to keep the Mk3 radars up to scratch in France. This they did, but quickly became involved in designing ways of using the equipment for much more than Anti-Aircraft work.

The reports from the Field show both aspects of their work. They also acted as liaison staff between ADRDE and Field Units whereby we received regular information on any unexpected failures in the Field, and for which we could work out remedies, to keep units in good form.

Similar Monitor Vans were set up at ADRDE for other types of Equipment, such as the American SCR584 Automatic tracking AA radar and the special AA No 3 Mk4, built as a crash programme to give the Army a light weight Automatic tracking AA Radar, and the special Shell Splash Radar, to give instant correction of firing errors against ships, especially MTB's. (The GL3 weighed some 11 tons, and the SCR584 some 12 tons. The AA No 4 Mk 4 was only 4 tons). These all carried a basic and special Test Gear.

(54) EKCO Airfield approach Radar

This is the descriptive pamphlet of a small compact radar, direction finding system and VHF Speech radio, designed for mobile use and setting up on temporary airstrips, or mounted in permanent buildings on small airfields. Parts, particularly the radar and display have been used by the army on their own, to monitor shipping movement on estuaries, showing the versatility of the concept.

(55) 'Combined Operations 1940 - 1942'

This is a 'Book' issued by the Ministry of Information in 1943, one of several books designed to boost morale in the UK during the long wait for the promised invasion to start, and to show that all was not static, but that there were ongoing actions many of course not made public with blaring headlines etc.

The reason for including this book in the Radar Archive is that one of the Chapters (p. 45 Ch. 9) deals with the attack on the Radar station at Bruneval, where a new type of Radar, the 'Wurzburg' had been installed, and the authorities and radar establishments in UK wanted more information. The raid was intended to bring back as many of the salient parts of the equipment as possible. In this they succeeded. The technical part of the attack is best seen in the account by Prof. R.V. Jones in his book 'Most Secret War, and in others.

See also Files such as File 48 (EKW22) and File 50.

NOTE that the radar concerned was the small original type Wurzburg, NOT the Giant Wurzburg

(56) Data Summary and Index for RADAR Equipments

Originally produced by the staff of the School of Anti-Aircraft Artillery, about 1950 (Reprint 1955)

Includes: RAF Equipment
 Br. Army A.A. Equipment (Includes Canadian and USA Equipments by
 British Numbers.
 Br. Army Coast Artillery Equipment
 Br. Army Field Artillery Equipment
 American (US) Equipment
 German Equipment

The Japanese Radar Equipments (mainly Naval) were not generally known until 1985.
Russian Equipment was never officially revealed and was not included in this list (although fairly well known) to prevent claims of espionage!

(57) Search-Light Control (by Radar) - SLC - 'Elsie'

An article written specifically for the RAF Neatishead RAF Radar Museum following a request, 'What is or was, 'Elsie'? '

Contents: Original Manuscript

Submitted version*

Printed version*

* The submitted version was too long to print, but was put in the Museum Archives.

- (58) This is a collection of Obituaries collected from Newspapers and Learned Society Journals, as well as some specifically written by DHT for the RRDE Annual Reunions

This is not a comprehensive collection, but one which at least covers some of the figures in or connected with wartime and post war radar, some of whom spent at least part of their careers at TRE, ADEE/ADRDE/RRDE and other associated establishments and companies. Some are people who, while not involved with radar, non-the-less provided an input, whether hardware, techniques or theory to the later development of radar. Some are historic, which DHT has come across when searching for other purposes e.g. Kelvin.

The index is in no particular order, but where necessary, the entries themselves give reasons for inclusion. Two folders contain letters and groups of obits. being those collated by DHT for the RRDE Reunions at Marlborough in 1999 and 2000.

Contents:

1. F.A.Lindemann (Viscount Cherwell)

Eminent Scientist from Oxford who became Churchill's personal scientific adviser when Churchill became Prime Minister in 1940. Much of his work included radar advice and consideration of German radar methods and objectives. He was apt to make snap decisions on the usefulness of some UK projects, and in a few cases no doubt delayed the deployment of what later proved to be winners, e.g. H2S and Oboe. He also had a tendency to promote his own ideas, even though, after study they proved to be of no value, e.g. Balloon-borne bombs to destroy enemy aircraft.

Phys. Bull. 1988 (37)

2. Jack Wettel

One of the original members of the Search Light-Establishment of 1918 and of the Search-Light Section of the London Electrical Engineers (TA), 1916. He later, at RRDE, used his engineering background to find suitable small firms to assist RRDE main workshop in maintaining their production capacity when work pressures were high (and frequently overloaded!)

3. Sir John Randall

A Physicist with leanings towards Biology. After industrial experience, he moved to Birmingham University, and after studying fluorescence, with the start of the war in 1939, the Physics Dept started research on possible means of producing higher powers on centimetric wavelengths than had previously been attained, and with Boot, (a student) as assistant, they developed the Cavity Magnetron a World (and War) winner. In 1944, he returned to academic life in medical biology, but as a physicist.

4. Wimperis

Although he had to overcome many difficulties (poverty, etc.) in his early life he became a learned aeronautical engineer and after a spell in industry, he joined the Civil Service as an engineering adviser and during the WW1, joined the Air Ministry, where he set up the Air Ministry Science Laboratory and was later made the Air Ministry Director of Research. It was in that position that he set up the Committee on 'Scientific Survey of Air Defence', the 'Tizard Committee', (at the suggestion of his secretary, A.P. Rowe) and with A.P. Rowe as its Secretary, quickly lead to the embryo development of Radar, originally for the RAF, but by 1937 involving all the British Services.

5. John M. Robson

A talented Physicist, who, as his first job after graduation, was sent to ADRDE at Christchurch, Hants, and there joined the group working on the GL3 (an anti-aircraft radar operating on 10 centimetres), led by Drs Shire and Dunworth. He was almost immediately given the task of studying and then demonstrating a means of converting the manually controlled experimental set, to be controlled automatically in bearing and elevation by deriving error signals from the radar signals returned from aircraft targets. Robson studied the characteristics of various servo forms and built such a set using a Metadyne, into the prototype radar B 1. He again studied the resulting set and refined the characteristics to give optimum results. This was followed by simpler means of attaining high acceleration by using split field DC motors. Again refinement of the Servo constants produced a tracking accuracy of a 4ft diameter aerial 10cm radar, tracking a propeller driven aircraft, of 7 to 9 minutes of arc and on a special version with 6ft diameter mirrors of 5 minutes of arc. This set continued in use by RRDE as radar-theodolite until superseded by the BTH built 3cm 'Yellow River' Radar. These accuracies were considerably improved on jet propelled aircraft. John then became the Station adviser on servo systems and tracking, before being encouraged by Cockcroft to join his team at the Chalk River Atomic Energy Establishment in Canada. He remained in Nuclear Physics for the rest of his life in Canadian Universities.

6. Charles W. Oatley

After graduating he worked under Appleton at Kings Coll London. At the start of WW2, Cockcroft invited him along with others to join his radar team. He had in 1932 written a book 'Wireless Receivers' as a Methuen Physics Monograph, which later was to become an invaluable text book for Physicists thrown into radar, without prior knowledge of radio. This team was assisting the RAF to modify Army 150cm Coastal Defence Radars to gap fill the vertical polar diagram of the RAF CH stations. Subsequently, these people moved to TRE and ADRDE, but mainly the latter, where they joined the various technical groups. Oatley set up the Test Gear Group at ADRDE, becoming its head, and instigated the Measurements section, providing standards of comparison. After a spell as Chief Superintendent when Cockcroft went to Canada, he left RRDE to return to Cambridge, becoming the Professor of Electrical Engineering.

7. R. Andrew

After receiving his PhD from Cambridge, Andrew was sent to work at ADRDE at Malvern in 1942, working on a variety of radars and application systems, including aerial design, wide band receivers. He stayed until 1949 when academia called and he ultimately became a leading authority on NMR (Nuclear Magnetic Resonance). He became Head of Physics at Nottingham and after retirement went to live in Florida in 1983.

8. Fred Hoyle

Mainly an Astronomer, but spent part of WW2 working in the Admiralty on Radar.

9. Lord Kelvin

(Not easy to read, due to print size and age of the original)

No direct connection with radar or radio, but his scientific work has provided a base for almost all science since him and is relevant to later research and development work.

10. Keith Runcorn

After a Cambridge education, Runcorn joined ADRDE at Malvern in 1943 and worked under Oatley in the centimetric measurements section and later in the Special Radar Section, leaving in 1946 to work under Blackett at Manchester University. His interests were mainly in Geophysics, and it was while attending a conference in San Francisco on that subject that he was murdered in his hotel room in San Diego.

11. Maurice Foulkes Roberts

Originally trained as an electrician, he worked in the 1920/30's in the electricity supply industry, spanning the time when electricity generation was turning over from DC to AC. He was a member of the IEE from the early 1920's. In 1935 he joined ADEE at Biggin Hill to work on sound location, leading him into the design of sound amplifiers involving audio transformers. He became an authority on the design of these. During WW2, this expertise led to his becoming an adviser to the ADRDE Workshop transformer design and manufacture section. He continued in this role after the merger of TRE and RRDE in 1952/3 and then joined the Component Design Section under G.W. Dummer, and this in turn led to his chairmanship of the Inter Service Committee on the R & D of Magnetic materials.

12. P.B. Moon

After Physics research at the Cavendish Lab and Imperial College, Moon was appointed to an Associate Lectureship at Imperial College in 1931. Here he continued earlier work under Oliphant on Neutrons. In 1938, Oliphant moved to Birmingham, and Moon joined him there in 1939, but Cockcroft tried to recruit him into his Radar team assisting the RAF on radar. He however continued with Oliphant and joined the team at Birmingham studying the problem of generating high power at micro-wave-lengths and suitable receivers. However as a result of this he was appointed to the Office of the British Supply Council in N. America, and reported back on many centimetric developments in many USA companies. His expertise on neutrons had led in 1940 to his being appointed a member of the Maud Committee. He returned to Birmingham in 1942 to a mix of centimetric and nuclear work. He moved to Los Alamos in 1944 when it became obvious that it was better to work with the Americans on the Atomic Bomb, rather than on the rather weak British effort. He was one of the observers of the first atomic explosion, making measurements associated with it. He returned to Birmingham in 1945, by which time centimetric work had ceased, and all effort was on the nuclear problems.

13. Jack Allen

Researched vision for his PhD (1933) and then with a National Research Council Fellowship (tenable only in USA), he went to Cal Tech and in 1935 came to Cambridge, intending to work with Kapitza, who unfortunately was prevented from returning to UK after visiting his mother in Russia. He worked in Cambridge on a number of subjects, but on the outbreak of WW2 worked on artillery instrumentation, developing a new accelerometer to measure acceleration of shells (leading to the

recognition of the unreliability of artillery fuses). This spurred the work on proximity fuses, (work already in progress at ADEE) The PF was revealed to USA by the Tizard Mission in Aug 1940. After the War, he returned to Academia, firstly with the Chair of Natural Philosophy at St Andrews.

14. Geof Dummer (IEE News, Malvern Gazette, Letter to Malvern Gazette)

Dummer became well known early in the war when he analysed electronic failures in airborne equipment, mainly in bombers. He decided that the main problem was that of water condensing on the intensely cold equipment as the aircraft dropped height from high flying levels to the airfield recovery height. His solution was to encapsulate the equipment in cylinders (for strength as pressures changed), effectively sealing against ingress of damp air ('Dummer's Dustbins'). This led after the War to a study of component failure in general and he advocated a series of standardised tests before acceptance irrespective of manufacturing source. This was implemented by a series of specifications fixing mechanical size (important for inter-changeability), contacts and electrical characteristics. These were rationalised with USA specifications, and then with EC specs, resulting in general EC specs to cover all users.

15. George Sowter

Dr Sowter was well known in the 1930's along with P.A.G.H. Voigt for innovative designs of loud speakers, which led later to the everyday HiFi speakers of considerable power. His work on magnetic materials particularly MuMetal was of considerable importance in radar and instruments employing cathode ray tubes (magnetic screening preventing strong magnetic fields interfering with the electron beams) and RhoMetal in high performance wideband RF and IF amplifiers. His later move into audio transformers provided a source of high quality components for both research purposes and for mass production of these items for Service use.

16. F.C.Williams

A brilliant circuit design engineer, but who was (and probably still is) best known for his outstanding work in turning a crude DC motor for servo control, designed by Blackett, into a truly remarkable high performance, high production repeatability, high accuracy split field servo control motor, with a DC feedback generator on the same shaft (The Velodyne), whilst he was at TRE in Malvern. Its sensitivity, linearity and low inertia made possible small accurate servo controlled mechanisms, for use in auto-follow systems and (such as) pen plotters. Larger versions with similar characteristics were likewise designed for larger applications.

17. 'Coppo' Lewis

An example of a man who turned youthful excursions into simple radio and electronics into an extraordinarily successful commercial career. The Naval Comprehensive Display System he developed at Elliot Bros (Directed by Benjamin of ASE) ran parallel with similar systems developed at RRDE at Malvern for the Army (and later the RAF), and by TRE, also at Malvern for the RAF. The analogue data storage systems were of high accuracy, some 6 to 10 years before digital systems began to overtake them.

18. Robert Clayton

Robert was one of a rare breed of Electrical Engineer, who spent his whole life from first-post graduate job right through to retirement with the same company, in this case GEC, and was stationed for the most part at the Research Laboratories at Wembley.

When Weinstock took control of GEC, he recognised Clayton as the best technical advisor he could ever hope to have. Weinstock was essentially a financier, and had no interest whatsoever in technical matters, so long as they were financially rewarding. Clayton however had a wide knowledge of all the work going on in the scores of different GEC factories, but as overall managing director, had a difficult task in maintaining a credible research base, since it in itself provided little financial gain; and mainly was a financial drain, and he had difficulty maintaining it as a basis for new products.

He was highly respected throughout the electrical and electronic industries and continued to influence many learned institutes, long after his retirement.

19. John Mills

Involved in wartime airborne radar for the RAF. He joined AMRE whilst it was at Dundee, following the removal from Bawdsey (which was taken over by the RAF as a Service station), and before relocation at Swanage in late 1940. He had subsequent experience at several Government research establishments, becoming Director of SRDE at Christchurch in 1967, and subsequently deputy director of RSRE after the merger of SRDE and RRE at Malvern.

20. Arthur ('Arlie') Bailey

Arlie (as he was always known) spend many of his years at Government Research labs, as a 'One Man Think Tank', frequently coming up with rather startling suggestions, many of which seemed on the face to be irrelevant or time wasting. It was always necessary to sit down with his writings and to analyse them carefully, at which stage, their true value (usually) became clear, and mainly brilliant! He had several spells at the Army Radar Establishment, ADRDE/RRDE/RRE in between spells elsewhere at the Government Communications Establishment and SRDE. He subsequently went to the NPL where he started the Electrical Services Division. Before retirement and in retirement he was a leading proponent of the creditation system for engineers and scientists, and took leading parts in the IEE and Inst. Phys. systems, working alongside Mechanical Engineers and Chemists. After retirement in 1980, he kept in touch with his past colleagues at RRE and was President of the annual gathering at Marlborough of the 'Air defence Reunion' until his death.

21. Ernest Rutherford

Strictly not an obituary, but a review of a book about Rutherford published in 2000. Rutherford died in 1937 and probably knew little or nothing about the up and coming British Radar System. Yet his influence carried on. Those who came from Cambridge to the various radar and electronics development establishments at the outbreak of war and in subsequent years, brought with them the 'Rutherford Method', an unwritten but powerfully instilled desire for truth and the rejection of anything unproven. His 'string and sealing wax' approach to experiment and research percolated into the Establishments and out went the slow procedure of producing impeccable machines built to prove a point. 'Bread-boards' and even Meccano ruled the day, and results came quickly, 'for' or 'against'. If 'for', then more detailed experiment was in order. Amongst his 'pupils' were Cockcroft, Dunworth, Shire, Ashmead, F.E. Jones, Robson, Oatley, to name but a few. DHT considered that his influence was one of the major factors in driving the development of radar in time to help win the war.

22. D.R. Chick

After a spell 1937 to 1940 at the War Office 'Signals Experimental Establishment' at Woolwich working on military communications and jamming, he transferred to ADEE at Christchurch and was responsible for 'Elsie' (Searchlight control radar) and also worked on 150cm coastal defence radars, moving to Malvern in 1942 with ADRDE. Here he worked on numerous army radars, including some on 3cms. He devised a set for detecting and plotting mortar bombs in flight, in order to determine their source (projector). Unfortunately the set had severe mechanical problems, and operation was shown to be based on a false assumption and sets never reached the Field Army.

After the War he left Government Service and joined AEI (Allied Electrical Industries) who were picking up isotopes from the Atomic Energy Reactors at Harwell and making commercial isotope packages for industry. From there he went to the Walthamstow Technical College, and when this became the University of Surrey, he became Professor of Electrical Engineering. Chick was a fine engineer and a 'Thinker' but mostly a 'Go and Do It' enthusiast, (He completely rebuilt a Miranda Sports Car), but unfortunately had little theoretical acumen and was inclined to say 'So what'. A much loved personality, who stuck up for the under-dog.

23. Ernest Clive Slow

Clive started his working life in the shadow of the Portsmouth Dockyard, following his father as an apprentice engineer there. He set about educating himself and was rewarded with a London B.Sc. (external) and then found his first job at the Slough Radio Research Station, where his work with Watson-Watt and Wilkins drew him into the radar story, and provided him with a wife, Dr Mary Taylor, a brilliant mathematician. She it was who had done most of the calculations for Watson-Watt and Wilkins when he was presenting his evidence about 'Death Rays' and the possibility of aircraft detection to the Tizard Committee. When they married, under Civil Service Rules, she had to resign her post, losing for the Scientific Civil Service one of its most outstanding mathematicians. Clive was seconded to Bawdsey Research Station, and from thence he went to ADEE at Christchurch at the outbreak of war. He remained with the Establishment on its subsequent move to Malvern. During his time at Christchurch, he did most of the design work, including the aerial system for the Army GL2 equipment and saw it into production at EMI (aerials and display system) and Metro Vickers (Transmitter). At Malvern, he oversaw the development of a 25cm radar for close control of the Bofors gun.

24. R.V. Jones

R.V.J. was a product of the Oxford Science Wing, and early in his career came to the attention of Prof Lindemann. Lindemann was in turn to become the right hand scientific adviser for Churchill when he became Prime Minister in 1940. After Jones gained his doctorate, he was first an infra-red researcher and then turned to astronomy, but at outbreak of war he returned to infra-red to investigate possible means of detecting enemy bombers using their hot exhaust gas. He then joined the Air Ministry, there to find the paucity of intelligence on German military science, and he set about trying to update the information. Using his 'powers' of 'reading between the lines' and discovering previously undetected weapons on photographs, he was the first to detect the German 'Wurtzburg' radar aerial. This led to a more detailed examination of the papers given to the Br. Consulate in Sweden, which had warned of the 'Aerial Bowl' and had also details of both the V1 and V2 weapons. In the autumn of 1940, he postulated the use of guidance beams by the German bombers, and ultimately these

were detected and measures taken to reduce their effectiveness. Lindemann was in a position of influence, guiding Churchill and he frequently disparaged what Jones was doing and saying. Jones began to advise the RAF direct, whilst still reporting to Churchill, and fortunately, much of what he said proved to be near correct. RV was a stubborn man in many ways, and if convinced of something would do all in his power to press his point of view.

DHT's own experience of this came after he had read his 'Most Secret War' and he spoke to Jones regarding his question therein, 'Why were there two parallel lines of bombing in a raid on Birmingham?' (DHT also knew of similar pairs of lines in Sheffield), and he said, 'Surely because they were using a Lorenz type meter display, and pilots liked to see the edge of their moving needle beyond the side of the fixed marker needle, and some might be in error on the left and others on the right'. He pondered this for a while and said 'I've puzzled over that for a long time and you come up with a simple solution. When I go to Germany, I'll quiz some pilots'. When DHT met him some years later at Staff House in Aberdeen, he asked if Jones had solved it and he remarked, 'You might well be right!' That occasion confirmed his stubbornness in another way. It was obvious that he was in great pain walking and very slow, and DHT offered to give him a lift back home, a distance of about half a mile which he promptly refused, saying, that the walk would limber him up for his climb to the 7th floor of his apartment block. Stubborn indeed.

25. Lt. Col. H.S. Young

Known by most as 'Buster' Young, a name he was very happy with, acknowledging himself as such on the telephone ... if he recognised the voice of the caller! He was essentially and for most of his career, 'one of the boys' no matter his personal status. He had an enormous sense of fun and could defuse arguments or stalemates at meetings and even conferences, by introducing a 'sideline' or even cracking a joke. After any ensuing laughter, he would quietly explain why both parties were (a) 'wrong' or (b) 'absolutely on the right lines'. He had a slight stammer, and he would introduce it when he wanted to emphasise a point. Usually when somebody stammers, the listeners will be quiet and still until he recovers the required words. He made the best of the opportunity. Some of his jokes inevitably centred on the impediment, sometimes introduced deliberately for effect!

He joined the new ADEE at Biggin Hill in 1924. He was in the T.A. and was mobilised at the start of WW2, with postings circulating around the War Office, Ministry of Supply, and the Establishment (ADRDE, RRDE). He returned to the RRDE at the end of the War, in various superintendent positions, but left on the amalgamation of RRDE and TRE in 1952/3. Initially he went to MOS headquarters, but then became DD of Scientific Intelligence. His 'after dinner' speeches were most memorable, and are a lasting memorial to him, particularly those made as chairman of the Air Defence Reunion, which usually centred (kindly) around some noted personality in the establishment, and invariably embodied his stammer (to good effect).

- 26 & 27. Two folders which contain obituaries for members of the Establishment (ADEE, ADRDE, RRDE, RRE) written by DHT for the Air Defence Reunions. Also enclosed are letters from members not attending.

28. Ernest Putley

A Member of TRE from 1942 to retirement, who became a historian of what TRE had done during the War Years and later. Entries, one from Malvern Gazette and the other from the Newsletter of the RAF Radar Museum at Neatishead.

29. Sir Edward Fennersey

An early member of the AMRE (Air Ministry Research Establishment at Bawdsey (later TRE)). After the War, he joined Decca Navigator Co. and subsequently became the first managing director of the Decca Radar Co.

(59) ADRDE/RRDE Staff Lists for various times and purposes

1. Putative complete list of staff drawn up for the Passive\Air Defence Officer Mr Harry Burns shortly after staff arrived at Malvern in 1942. Drawn up so that personnel could be accounted for in the event of an 'incident'. It shows the appropriate commitment of each individual, e.g. Fire Watcher, CCCivil Defence Air raid warden (both outside the Establishment) etc. An important entry for most fire watchers is the National Identity Number
2. List of non-industrial staff at RRE in 1957, i.e. after the merger of RRDE and TRE to form RRE. This gives the Rank and date of appointment to that rank and includes date of birth
3. List of personnel who attended early Air Defence Reunions at Marlborough, 1954 onwards
4. A list of staff (NOT COMPLETE) (ADEE/ADRDE at Malvern who were known to have been at Christchurch
5. Scientific staff at ADRDE (Malvern) before the name change to RRDE in 1944
6. Scientific and Engineering staff at ADRDE/ RRDE in 1944, showing the groups and sections in which they worked and the senior officers and responsibilities

(60) TRE (Telecommunications Research Establishment)

Staff Chart showing Group Heads and Staff at 1943 (other charts may come to light)

(61) Air Defence Experimental Establishment - Early papers of historic value

1. ADEE was formed in 1922/3 by the fusion of the Searchlight Experimental Establishment (formed in 1919) and a group from the Signals Experimental Establishment, who had been working on improved forms of sound locators for the detection of aircraft. By 1936, however, the main principles of radio detection of aircraft had been formulated mainly by an air ministry group working at Orford Ness and then at Bawdsey, the Bawdsey Research Station, with a War Office group of scientists in attendance, to learn as much as possible about what was to become Radar.

Watson Watt was the head of the BRS and the senior officer of the War Office Group was Dr. S.T. Paris. Watson Watt requested a critical review on what Paris saw of the future of sound locators. This paper is Paris' response, dated 3 December 1936.

2. Setting up the ADEE Social and Sports Club
ADEE when formed in 1922/3 was located at Biggin Hill on the WW1 London Defence Airfield. There were still the RAF (RFC) buildings intact including the messes. ADEE made use of these facilities, but they didn't own them. Nevertheless, the requirement of provision of mess facilities for industrial staff was met. (There was no such requirement for non-industrial staff). However, ADEE was a lodger organisation on Air Ministry property, and it was decided in 1936/7 that a new site should be provided for ADEE, and a suitable place at Christchurch was found and plans made for the new Establishment to be built for occupation in 1940/41. The imminence of war in August 1939 meant that the RAF wanted back their Biggin Hill airfield and ADEE had to move out rapidly. However since this was a new site, there were no existing mess facilities for the industrials. This problem was foreseen by Costello the Superintendent and Forshaw the head of the WO group at Bawdsey at that time, and they devised proposals whereby a Social and Sports Club could be set up for use by all, industrial and non-industrial, effectively owned and run by the staff. These are the papers dealing with the situation.

Footnote: the £2000 loan was repaid by the time the Establishment moved to Malvern in 1942.

3. A personal letter from Costello in retirement to Harry Burns, which gives the story of the rapid moves of ADEE from Biggin Hill to Christchurch and similarly the War Office Group from Bawdsey. The original is handwritten, and this is a typed transcription.

(62) Radar anti-jamming techniques, M.V. Mahrimov et al, 1976

One of the first books to be published on anti-jamming techniques. It was a Russian publication and was at the time viewed with some suspicion in the West, because the Soviet Radars and Allied techniques had been kept very secret. It was only after very careful analysis that it was recognised that it was a means of indicating to the West that 'All is known'.

It covers most of the means used by the West (up to about 1970) to reduce the usefulness of Radar, particularly in Defence terms.*

Most of the techniques described had been in common use from about 1943 (on a small scale and in unsophisticated forms and redeveloped in conjunction with more modern radars after that).

* Deliberately, the term 'reduce the usefulness' has been used rather than 'defeat'. It was realised by 1943 that for any form of jamming, there would be palliatives but seldom cures.

(63) Radio Instruments and Measurements. US Bureau of Standards, March 1924, 2nd Edition. Circular 74

This book in the period 1935 to 1944 (the formative years of Radar design) was a prized possession of anybody lucky enough to possess or have access to one.

By that time, the frequencies in use in radio and more so in radar had moved significantly upwards but the theorems were still of vast use, especially for those who were new to high frequencies (radio and radar). It gives classic examples of instruments which were adapted to the higher frequencies and the METHODS of measurement, likewise adapted. The first book published which covered these frequencies in their own right was the MIT book on Radar Design in 1943.

This copy was originally owned by Percy Hibberd and was recommended to him when he joined Muirhead & Co. in about 1934. It went with him to EMI (405 line TV and Stereo recording Blumlein ..) in 1936, and to Bawdsey 1938 and TRE 1941. On retirement in c1975, he donated it to DHT, having noted that DHT's own copy (1937) was simply a series of loose pages due to the extensive use by DHT and many associates who didn't have access to any other copy!!!

(64) The London Electrical Engineers

About 1907, a group of Senior electrical engineers in London agreed to form a body with the promise of 'assistance to the country (England) in the case of need'. When the Territorial Army was started, this body joined and formed a specific battalion, 'The London Electrical Engineers, Territorial Army', with a headquarters in Regency St London.

They trained in:-

(1) Electrical power generation, fixed and mobile, including Diesel, gas, oil, petrol and steam, as the driving source

(2) Telephones and telegraph, overland cabling, local and central exchanges, and field telephones

(3) Searchlights for Coastal Defence

At that time there was no threat of airborne bombing or invasion, so the role of the searchlight in the army as for the navy, was to illuminate sea borne incursion or threat thereof. Searchlights were sited on coastal stretches where it would be relatively easy to land troops, especially in estuaries and port entrances. On estuaries a fixed beam was used, pointing just above the water surface, giving ranges of up to 5 miles for a periscope, using binoculars. And if the searchlight was on a cliff up to 50 ft high, the range could be increased to around 10 miles. Frequently, searchlights were deployed in pairs, one on each side of the estuary, to give parallel beams some 200 yards apart (spaced to avoid blinding the observers on the opposite bank).

On open coastlines, the beams were scanned across the area at about 1 degree per second covering some 30 degrees either side of centre (manually). The actual coverage depended entirely on the topography and threat.

On outbreak of War in 1914, most of the London force was deployed at points along both sides of the Thames estuary.

Other similar groups had been set up in populous areas elsewhere in the country, and these were generally deployed to cover harbours and estuaries in their areas.

This particular deposit is of the 1914 issue of Regimental Orders for the LEE(TA) and lists of men involved. Elsewhere are to be found articles about the LEE and the magazines published by the LEE during the WW1 from their various sites.

In the rule book, there are names of some whom DHT knew since they were still at ADEE in 1940, including F.W. Moore (who donated the rule book), H.E.Harris, J.Tucker, H.W. Graham, C.W. Jacobs.

See also the History of ADEE etc. for the link with LEE (TA)

(65) Copies of 'Searchlight', the magazine published by the London Electrical Engineers (TA) 1915 onwards

See also Files 66 and 67

When the members of LEE (TA) were deployed at forts along the Thames Estuary in WW1, they started a (fully printed) magazine. This File includes Vol. 1 March 1915 to Sept 1915 and Vol. 2 Nov 1915 to Mar 1916 (April 1915 to Oct 1915 missing). Originally donated to DHT by F. W. (Pony) Moore.

(66) Copies of 'Searchlight', the Magazine published by the London Electrical Engineers (TA)

See File 65

This file includes Vol 3 April 1915 to Sept 1916

Note: DHT was informed that a complete set exists at the RE Museum, Chatham.

(67) Copies of 'Searchlight' the magazine published by the London Electrical Engineers (TA)

This file contains Oct 1916 and Dec 1816 (Part of Vol 4) and Oct 1917 (part of Vol 5).

Note: DHT is informed that a complete set exists at the RE Museum, Chatham

The following issues of 'Searchlight' were given by W.F.T. Moore to the RSRE Library Archives (now DRA) some time ago, and should still be there, unless they have been passed to P.R.O. (now The National Archives). If not, almost certainly destroyed by Qinetiq.

D.H.T. has photocopied all, as below.

File 65:

Vol. 1 No. 1 March 1915

Vol. 2 No. 8 Nov. 1915

Vol. 2 No. 9 Dec 1915

Vol. 2 No. 10 Jan 1916

Vol. 2 No. 11 Feb 1916

Vol. 2 No. 12 March 1916

File 66:

Vol. 3 No. 13 April 1916

Vol. 3 No. 14 May 1916

Vol. 3 No. 15 June 1916

Vol. 3 No. 16 July 1916

Vol. 3 No. 17 Aug 1916

Vol. 3 No. 18 Sept 1916

File 67:

Vol. 4 No. 19 Oct 1916

Vol. 4 No. 21 Dec 1916

Vol. 5 No. 29 Oct 1917

DHT thought 5(29) Oct 1917 would be the last copy Pony had before he returned to Regency Street (S.L.E.).

Note that the serial number is continued vol. to vol.

(68)

A copy of the printed article based on the lecture by Dr. Ed. G. Bowen at the Austral. IRE, Sydney on Feb 7 1946, 'The History of the Development of Radar, Part 1.

(Part 2 (The Military applications of Radar) was scheduled to be given on Feb. 21 1946).

(69)

Correspondence DHT with the Editor 'Transmission Lines', the Defence Electronics Historical Society publication, re the letters from Dr. Peter Waddell about prior knowledge by the early workers on the Cavity Magnetron of previous work and patents. References to meetings on 10cm valves in July and August 1940, Ed Bowen's lecture on Feb 7 1946, and personal (DHT) knowledge.

(See File 68)

(70)

Data on the parameters of Radar Approach Radars and surveillance systems

(71) The Birth of British Radar: the Memoirs of Arnold (Skip) Wilkins, edited by Colin Latham & Anne Stobbs

Arnold Wilkins was on the staff of the Radio Research Station at Datchet near Slough, which was directed by Robert Watson Watt. It was Wilkins who was given the task of calculating the energy required to destroy an aircraft, (Death Ray) and subsequently to detect an aircraft following requests from the 'Tizard Committee'. He was then given the task of building the equipment with which he 'demonstrated' the detection of aircraft , an experiment which has become known as 'The Daventry Experiment' in 1934.

The original Memoirs are deposited in Churchill College, whilst an edited and shorter version are in the Public Record Office. This book has been edited and produced for a wider circulation, along with comments and explanations by the editors. Colin Latham is an experienced Radar Engineer, having spent many years with the Marconi Radar Company in Chelmsford and Leicester.

(72) SD 0458 Ground Radar Stations, RAF. AMES Type 1

A.M.E.S. TYPE 1		INDEX	
CH		MINISTRY OF SUPPLY	
(Including "Buried Reserve" and "Remote Reserve")		CENTRAL LIBRARY	
Description	1.0	Buried Reserve Receiver Room...	4.3
Operational Performance	1.1	Remote Reserve Receiver Room	4.4
Technical Equipment	1.2	RF7 Receiver	4.5
Personnel Establishment	1.3	Calculator Room	4.6
General View of Station	2.0	Message Recorder	4.7
Typical East Coast CH	2.1	IFF Equipment	4.8
Typical West Coast CH	2.2	Arrays and Towers	5.0
"Buried Reserve"	2.3	East Coast Transmitter Towers	5.1
"Remote Reserve"	2.4	Base of Towers	5.11
Entrance to a CH	2.5	View looking up Tower	5.12
Example of Camouflage	2.6	West Coast Transmitter Masts	5.2
View through Camouflage	2.7	View at Base of Masts	5.21
Transmitting Equipment	3.0	Array Counter Weights	5.22
E. Coast Transmitter Room	3.1	Feeder Run	5.23
Do. different angle	3.2	Remote Reserve Transmitter Tower	5.3
Transmitter Control Desk	3.3	East Coast Receiver Towers	5.4
W. Coast Transmitter Room	3.4	West Coast Receiver Towers	5.5
Buried Reserve Transmitter Room	3.5	IFF Tower and Cubicle	5.6
Do. reverse angle	3.6	Works Services	6.0
Remote Reserve Transmitter Room	3.7	Switchboard in Receiver Block	6.1
MB3 Transmitter	3.8	Switchboard in Transmitter Block	6.2
Receiving Equipment	4.0	Do. West Coast Transmitter Block	6.3
CH Receiver Room	4.1	Ventilating Plant	6.4
Console Equipment	4.11	Gas Filtration Plant	6.5
Console Equipment	4.12	Emergency Power Plant	6.6
Radio Portion of Console	4.13	Do.	6.7
RF8 Receiver	4.2	Do.	6.8
		Do.	6.9

Also including: Light Warning (LW) - AMES Type 6, AMES Type 7, GCI Fixed, VHF Receiver Station Receiver Type R11322A, AMES Type 8(c) GCI Intermediate Transportable, AMES Type 8F GCI Mk 4 Intermediate Mobile, AMES Type 9 MRU, AMES Type 9 Mk 1, AMES Type 15 Mk 1(M) (COL/GCI/CHB), AMES Type 16 Fighter Direction, AMES Type 19, GCI Fixed Standby.

(73) Shore Radar Services AP2275E & CD0911

At the start of WW2, coastal attack was defended against entirely by the Army, but one of the radars used, the 11/2 metre CD No 1 (Coastal Defence No 1) proved so useful to the RAF for low elevation detection of aircraft, that the use of almost all of those sets was vested in the RAF, and re-named as CD/CHL (Coastal Defence and Chain Low). As the Army built up an armoury of other sets, mainly now centimetric and the 240ft high tower mounted CD 1 sets also fell the same way, many of the sets did continue the dual use, but in many areas, the defence changed from artillery to air strike. Some of the Army sets however were intended not merely as 'Detectors', but as accurate artillery directors, and named as Coast Artillery sets (CA No-).

This list includes many sets which were entirely RAF types, but now aimed at coastal defence as well as those of Army origin, and the foreword, introduction and functional list give a good picture of the uses of the Shore Radar Service.

The accuracy in bearing and range were dependant on the performance of the operators, and the figures quoted are very much exaggerated. Against ships rather than aircraft the accuracy was 15 to 20 yards, and the range discrimination (within a combined echo), was 20 yards with bearing 6 minutes of arc. In 1944, most of the coastal sets were modified to give errors in bearing and range using a 'Fall of Shot' modification of 7 minutes of arc and 10 yds in range.

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(74) SD0458 / AP 2276 (Copy 125 Aug. 1943)
Photo Record of Radar Ground Stations

See also File 72

Equipments Shown. Note AMES = Air Ministry Experimental Station (a term which persisted from the original Bawdsey experimental work)

AMES Type 1. CH :

AMES Type 2. CHL :

AMES Type 6 LW

AMES Type 7 GCI Fixed :

AMES Type 8 GCI Intermediate Mobile

AMES Type 15 COL, GCI, CHB

AMES Type 16 Fighter Direction

AMES Type 19 GCI Fixed Standby

(75)

Loose Photographs of an RAF Convoy, mustered for testing at TRE Malvern before going to France (Number not known) (photos 12 June 1944)

Other photographs of individual equipments possibly part of the above convoy.

Type 14, Type 16 and MEW (Microwave Early Warning. Long range) and 150cm Mobile GCI.

(76) Interservice Electronic Valve Specifications. Part 1

Electronic Valves Preferred List of 1963. The new types of valve coming into service, mainly of the new miniaturised forms are shown as complete specification sheets, giving all the parameters for each type, and the test specifications for them.

Most of these are in the CV 4000 onwards series, with a limited number of other and earlier types in the CV1881 to CV3946 range. By 1963, most of these latter were no longer available for new use, but had to be retained in specification form because they were in current equipment use. Special purpose valves are listed mainly in the CV5000 and 6000 Series.

NOTE: BEFORE COLLECTING THIS DOCUMENT, LAY A PROTECTIVE COVER ON YOUR TABLE OR READING DESK. THE PAGE RETAINERS ARE METAL AND PROJECT FROM THE BOOK 'BACKS'.

(77) Interservice Valve Specifications. Part 2: Semiconductors

Semiconductors began to appear in new Service Equipments in early 1960s and were recognised by being accorded a new numbering series, CV7000 onwards.

The Preferred list of valve types of 1967 is included.

Integrated Circuits (other than simple ones, such as voltage regulators) had not yet been 'invented'.

NOTE: BEFORE COLLECTING THIS DOCUMENT, LAY A PROTECTIVE COVER ON YOUR TABLE OR READING DESK. THE PAGE RETAINERS ARE METAL AND PROJECT FROM THE 'BOOK' BACKS.

(78) RCA Electronic Valve Specifications, Book 1

1) Receiver types

2) Transmitter types

3) Cathode ray tubes and associated rectifiers and waveform generators

4) (1936) Acorn VHF valves

5) Iconoscopes and Monoscopes

(79) RCA Electronic Valve Characteristics. Part 2

- 1) Transmitting types
- 2) Cathode ray tubes including monoscopes and iconoscopes
- 3) Phototubes, photomultipliers
- 4) Miscellaneous types
- 5) Miscellaneous types, thyratrons, UHF valves

(80) Photographic information and data books

In the 1940 period, there were only a few data books concerned with film types and processing including formulae, other than 'House' booklets.

DHT was in 1941 involved in photographing 1 microsecond pulses, to measure variable amplitudes, modulation of radar signals by moving aircraft and propeller modulation as well as measuring variable pulse lengths in the 1 to 10 microsecond region and to measure rise and fall times accurately. The only cathode ray tubes with adequate brilliance and extremely short persistence were special transient recorder types made by STC, and the only film was an X-ray type made by Ilford (BP1). DHT collected several data booklets both during the War and before, whilst at University, of which only a few have survived.

- (1) Agfa Handbook of Development. Believed to be about 1938
- (2) Ilford Formulae. (Possibly 1941, when DHT visited Ilford re high speed development)
- (3) British Journal Photo Almanac, 1943. (Cover Distressed)

(81) Proximity Fuses

This is an odd collection of individual papers with little connection with each other.

- 1) Letter from Russell Burns enclosing a copy of his paper to the IEE on Proximity Fuses (History) IEE Proceedings A Vol 140 No 3 May 1993
- 2) Letter from Monty Lemmon to DHT, enclosing a copy of letters between Alec Rangabe and Prof Allen, Sept. 11 1984 and subsequent letters between (see below). Letter was complaining about inaccuracies in an Article in 'New Scientist'
- 3) Prof Allen to Rangabe 13 Sept 1984 and attachment (front page on report on Shell vibration
- 4) Rangabe to Allen 18 Oct 1984.
- 5) Two photographs of VT Fuse. One is a rough case, typical of having been fired but without explosive. Samples were used for electronic proving and testing, without involving expensive prime shells.
- 6) F. Hayward to DHT Designation of 'Proximity Fuses'. Potted history of Fuses. Various sources. Undated

Ragabe came to ADRDE in 1941 from Hivac Valve Co, which before the war started to make miniature valves for portable radio and audio equipment. Rangabe was involved in such valve development, and was a very suitable man to join the fuse group to transfer his expertise. This connection was to cause friction with GEC Valve Development at the Wembley Labs. Patterson objecting to him trying to tell his people about miniature valves because they were already working on them (but most samples would not stand high g, which was the point of Rangabe's secondment). Prof Cockcroft had to intervene to prove R had valuable expertise, whereas Patterson regarded him as a commercial spy!

(82) Essay on British Naval Development

Note from Bruce Neal (Marconi Radar Systems, Chelmsford) to DHT enclosing letter to MRSL from Norman Friedman (Hudson Institute) June 20 1980 and covering an essay on British Naval Development (a very good overview, without much technical detail.)

- 1) Bruce Neal to DHT with enclosure (letter and Essay 16.9.1986)
- 2) Norman Friedman (Hudson Institute) letter to David Griffiths (Marconi Defence Div.) June 20 1980 (includes a 'plug' for Friedman's book)
- 3) Copy of Appendix 1 of a much bigger overview of Naval Design (includes margin notes by DHT re the connection between Radar Type 984 and the RAF Type 82, designed at RRDE Malvern)

(83) Correspondence Melville (B.T.H.) and DHT re photograph

Unfortunately, only part of the letter is here

- 1) Letter 13 March 1984. Part of letter to DHT regarding request for confirmation of identity of Radar equipment on a photograph (Source of Article and relevant publication not known)
- 2) Photocopy of article on European Physics Education. (Which suggests source is an Inst P source)

- (84) Correspondence Bruce Neale (Marconi Radar Systems) to DHT re book on Baird's connection with Radar
- 1) Memo, Bruce Neale MRSL to DHT 9.12.1986 enclosing:
 - 2) Copy of a review in 'New Scientist' 20 March 1986 of 'The Secret life of J.L. Baird' by Tom McArthur and Peter Waddell. Review by Barry Fox
 - 3) Review of same book by Pat Hawker in Television J. Royal Television Soc April 1986
 - 4) Letter 'Taffy' Bowen to Bruce Neale (MRSL) 27 July 1986
 - 5) Memo, Bruce Neale to DHT, 11.12.1986 covering:
 - 6) Letter from 'Taffy' Bowen to Bruce Neale April 2 1986 re 'Radar Days' (Bowen) and Baird

- (85) Correspondence Van der Hulst with DHT, sometimes via Bruce Neale
- 1) Initial list of important dates re British Radar. Request for verification
 - 2) Letter to Van der Hulst from J.G. Gough of RRDE, giving advice on radar usefulness of certain Cabinet Files in the PRO (National Archives) 2006. The letter is undated
 - 3) Letter Bruce Neale to DHT 11.11.1982 covering:
 - 4) Letter from Van der Hulst, explaining that he was writing a Thesis relevant to obtaining a PhD, but wanted more information. A list of questions included
 - 5) DHT handwritten answers to V.d. H. questions (4) above. Draft version
 - 6) See (5) above. Final version.
 - 7) See (5/6) above. Typed copy (by Bruce Neale's secretary) to DHT for any corrections 4.1.83
 - 8) (see 7 above). Corrected version returned to Bruce Neale 8.1.1983
 - 9) (see 7 above) Bruce Neale sent a Typed copy to Bill Melville at BTH, for comment. This is his noted copy
 - 10) V.d.H. to DHT 19 Jan 1983 thanking for information, commenting and requesting still more
 - 11) DHT to VdH with some answers to (10) above, 26 Jan 1983
 - 12) DHT to VdH with corrections to (11) above
 - 13) VdH to DHT, with more requests re copies of PRO docs
 - 14) Further revision of document of 4.1.1983 dated 15 Feb 1983 with covering letter to Bruce Neale
 - 15) DHT handwritten notes on 50cm work at ADEE
 - 16) Letter from VdH giving thanks to DHT 4.6.1983

- (86) Odd papers & letters, Bill Melville, Bruce Neale, Tom Pippitt
- 1) Tom Pippitt to DHT re a remark to Van der Hulst concerning Normandie radar. 22.2.1984
 - 2) Reply to (1) Typed but almost illegible 7 March 1984
 - 3) Bruce Neale to DHT re Guerlac's book Radar in WW2. 4.2.1984
 - 4) Bruce Neale to DHT answering questions (Mr Gibney had some photos of installations of Naval 284 set) and source of CH tower at Great Baddow
 - 5) Bruce Neale to DHT re loan of film of Guerlac book

- (87) Correspondence between Squ. Leader Frank Hayward, Historian of RAF Christchurch and the Trials Flying Unit and DHT

Many of these letters are undated, so DHT simply grouped letters with associated subjects

- 1) Information and photos of the Airspeed Works under construction 1940 and written comparison with German photo of 1940 (No copy)
- 2) Letter 18 Oct 1991 enclosing an article from 'Aeroplane Monthly' Jan1984, concerning the Soundlocators of the interwar years, at Hythe in Kent
- 3) Copy Photographs (loose) of GL 1, GL2 and a 15KV A Lister Diesel generator
- 4) Loose letter of 28.11 1983 with reference to name 'RDF'
- 5) Letter, 12 Feb 1991 enclosing diagram of ADRDE trials field at Somerford derived from local map and the equipments on a photograph of the site taken 16.7.1941 (see text) by an RAF Christchurch aircraft
- 6) Frank Hayward's attempt at a 'profile' of DHT! (based on DHT information)
- 7) Letter 2 April 1992 enclosing a short memoir about ADEE as it arrived at Christchurch in 1939 and some of the interesting activities (mainly to do with GCI for TRE as used in trials at Sopley. Also another copy of the Airspeed Photos (1) above, with identifications
- 8) Letter 13 Oct 1990 with diagram of trials field (ADRDE at Somerford) with identifications (must be post May 31 1941, since GL3 AO is shown this experimental equipment was shipped from BTH (Rugby) on Whit Sunday and was working at Christchurch by 4pm on 31 May
- 9) Loose photocopy of the first Mobile GCI at Sopley for trials

(88) Correspondence between Ian Shaw (Glasgow) and DHT

This is correspondence between Ian Shaw who was trying to write a detailed technical book, but had no technical background, and DHT, trying to show the technical substance in a non-technical way. However, Ian Shaw had unearthed some of the best photographs of GL2 TX and TR and of the GL 1 TX that DHT had seen

- 1) Letter 14 June 1991 asking for information on dipole aerials
- 2) Loose A3 sheets in reply to (1) above
- 3) Further queries along with set of photocopies of photos of GL1 and GL2. Various views. Undated
- 4) DHT reply to (3) above (dated 2.11.01) Original letter to Shaw appears to have been lost in the post. Fortunately, DHT had kept a copy

- (89) Pamphlets about Christchurch, Steamer Point and other points in the district around the Somerford ADEE site

These are published pamphlets. Some were used as background information when writing the pamphlet on 'ADRDE at Christchurch'. (Some DHT hadn't found at that time, and had to rely on other sources).

- 1) Steamer Point by Olive Samuel

This pamphlet ends with the purchase of the area by the War Office in 1938, to provide an outstation of ADEE overlooking the sea, so that experiments could be made on radars for coastal defence. The last paragraph says that the cliffs are unstable. At 2007, most of the cliff radar emplacements have collapsed into the sea, and only a narrow footpath exists between the laboratory parts of the site, originally about 150 yards north of the cliffs, and the present cliffs

- 2) Bure Homage, Mudeford by Olive Samuel.

This was a small stately home, bought by the War Office in 1938 to provide a headquarters building for ADEE . After the War Office had no further use for the overall ADEE site, (in the meantime used by the Signals Research and Development Establishment), Bure Homage was sold to a developer and was demolished. One of the bungalows on its site was occupied by Sq Ldr. Frank Hayward (See File 87)

- 3) Bure Farm by Olive Samuel

This was a small farm adjacent to the land bought by the War Office, which had in fact been part of the farm and the fields used for cattle grazing. Although there were cabins and buildings on the fields during the ADEE occupancy the farmer was allowed to continue grazing, and sensitive areas were fenced off

- 4) Christchurch Airfield by Allen White

This is a general history of the site, adjacent to ADEE which used the service of the RAF there (Special Duties Unit later the Trials Flying Unit) used to provide aircraft for testing ground based radars for ADEE

- 5) Military Engineering at Christchurch Barracks by John Barker

This Establishment was originally a part of the Royal Engineers, but although employing many civilian engineers, there always remained a core of RE personnel. The Establishment also provided heavy engineering services to ADEE, although its own workshop was capable of most engineering tasks, light to heavy. A number of the personnel transferred to ADEE to form a core of the new workshops there.

(90) (PW1) Papers from the late Prof. P.D L. Williams

This is the introductory File of a series of files containing technical papers, collected during his lifetime by Phil Williams (He was always 'Phil' to all who knew him), known universally for his work on Marine Radars, from their earliest days when they were principally on naval, through to those derived from the naval sets to help ocean going civil vessels, to the general civil radars used on even the smallest vessels, commercial and private. D.H.T. had to admit to not having been closely associated with Phil, but knowing him by repute, correspondence and telephone, the last at great expense both ways. He was a 'Tower of Knowledge' on the technicalities of simple and complex radars, and shared his knowledge with others in any way he could.

DHT was approached some years ago, to enquire whether it would be permitted to deposit his technical papers in the Radar Archive of the University of Sheffield, and permission was immediately given. They have been stored and collated by Alan Shaw, to whom D.H.T. extended thanks.

As with other group files, this is the introductory file and his other files will bear the same initial File Number (File 90) followed by his initials (PW) and a sequential number (1 to N).

Alan Shaw has provided this introduction to Phil Williams, for which DHT was grateful.

The Archive of Prof. P.D.L.Williams

Philip David Lane Williams was an internationally recognised expert on Marine Radar, both in its Civil and Military applications. He served in the Royal Navy from 1945 to 1946 and then studied at University College, Nottingham, and became a Vacation Student at the Royal Radar Establishment at Malvern in 1956.

He joined the Electronic Switching Laboratory of Ericson Telephones at Beeston in 1950 (??)* and two years later joined the Development Laboratories of Decca Radar, and became Head of Future Projects in the Company in 1969.

In 1975, he received the Institution of Electrical Engineers 'Brabazon Premium' and in 1977, the 'Clarke Maxwell' Premium in recognition of two of his many published papers. Much of his work was on the relationship of various theoretical approaches and practical results, demonstrating that the complexity of radar performance at sea was not amenable to mathematical modelling.

He was a keen yachtsman, and a member of the Institute of Navigation for 48 years. He participated in the 'Circumnavigation of England and Scotland' by the Decca Radar Company's demonstration yacht.

His experience with Decca covered a very wide field, from microwave ovens to meteorological and marine radar.

After his retirement, he continued to be very active in the Institute of Electrical Engineers, both in helping students seeking admission, and in papers on the education of future engineers. He was invited to revise the late Merrill Sholnik's 'Radar Handbook' and he was actively working on this update when he died after a short illness, on December 25th 2005, aged 79.

* There is the question of an error here. Should this date be 1960?

(90) (PW2) Typescript of Prof. P.D.L. Williams' book on 'Marine Radar'

This File contains the Volume 1 of this monumental work. It is prepared for the printer, but apart from a few Photocopies, for special friends, has not been printed. Volume 2 is to be found at File 90 (PW3).

The book covers a very wide field, reviewing many Marine Radars with some detailed descriptions. It also contains considerable mathematical approaches to the theory of navigation and the application of radar to this.

There is also a CD associated with both volumes.

(90) (PW3)

This file contains Volume 2 of Prof. P.D.L. Williams' typescript of his book 'Marine Radar'. For Vol. 1, see File 90 (PW2).

This volume continues Prof. Williams' comprehensive descriptions of Marine Radars, with considerable theoretical content.

(90) (PW4) CDR PDW6 No 1. Civil Marine Radar

The previous two files relate to Phil Williams' book (in two parts) written in about 1998 but never published. He did however photocopy the text, producing a small number of copies which were bound. He quotes the cost as being around a hundred pounds per copy. He then revised the book, bringing it up to date up to around 2002. At this stage, he decided that the cost of publication would be astronomical, and that his best course would be to record the text on a CD Rom and to circulate copies to all whom he knew and thought might be interested (free of charge). He seems to have circulated around 200 copies over a period of time. A copy of the list of intended recipients is to be found in a later file. The compiler of this index has deliberately said 'intended recipients', since we have no means of knowing how many were sent, nor how many were safely received. There is no indication of the actual addresses and the title of the recipients is frequently rather vague. (DHT is shown simply as Ex ADRE, Malvern, (should be ADRDE up to 1952) whilst he retired from the successor Establishment DERA, in 1979, and the Establishment by 2002-4 had been in the hands of QinetiQ for several years, where there is no historical record of previous staff). No copy was received.

The discs contain some other related material, such as a potted history of Decca Radar (mainly the Marine Radar Division), and a copy of the paper published in the GEC Review, of the post war history of Marconi Radar Division, written by Bill Eastwood et al and some later thoughts on aspects of Marine Radar.

The Sheffield University Radar Archive have been donated two copies of the complete CD ROM, PDLW6 - copies No. 1 and No. 2 which PW had obviously kept for himself, and this copy is No. 1. IT IS INTENDED THAT THIS COPY WILL NOT NORMALLY BE ISSUED TO INTENDING USERS BUT RETAINED AS A REFERENCE COPY IN CASE OF DAMAGE TO THE SECOND COPY which is in File 90 (PW5).

However in order to avoid much use of the Discs, photocopies of the books have been made and installed in albums, which are available at File 90 (PW6) Part 1 (Ch. 1 to 10), File 90 (PW7) Part 2 (Ch. 11 to 20) and File 90 (PW8) Part 3 (Appendices).

(90) (PW5) CDR PDW6 No. 2. Civil Marine Radar

PLEASE REFER TO File 90 (PW4) for information about the CDR contents.

THIS FILE (File 90 (PW5)) CONTAINS THE USER COPY OF THE CDR PDLW6, the text of 'Civil Marine Radar' by P.D.L. Williams.

The Contents are identical with those on Disc 1 and are as follows:

- a) List of intended recipients, in batches 2002 to 2005
- b) Decca Radar: Historical Notes on the Radar Development Division, Phil Williams, 2004
- c) Notes on this year's holiday on 'Sea Tramp' (2005)
- d) Civil Marine Radar - a fresh look at transmitter spectral control and diversity operation
- e) There appear to be 2 further items, but they could require passwords, which are not known

(90) (PW6) Notes on the CDR6

(90) (PW7) Text of Book Pt 1 Chapters 1 to 10

This and the contents of File 90 (PW8 & 9) are bound copies of the texts of the CDR6.

There is a full Chapter index in File 90 PW6 and in each of the bound copies, covering all three parts.

(90) (PW8) Text of Book Part 2 Chapters 11 to 20

This and the contents of File 90 (PW7 and 9) are bound copies of the texts of the CDR6.

There is an index to all Chapters in File 90 (PW6) and also one in each volume covering all chapters in the 3 volumes.

(90) (PW9) Text of book Part 3 (Appendices)

This and the contents of File 90 (PW7 & 8) are bound copies of the contents of CDR6.

There is an index to all chapters in File 9 (PW6) and also one in each of the volumes, covering all volumes.

- (91) A Potted history of the events leading up to the Development of GL3 anti-aircraft radar for the British Army

In a discussion over lunch at Marconi radar (Leicester) in early 1987, Tom Nuttall expressed his regret that there appeared to be few historic radar records in the Company (previously B.T.H.), and DHT protested that there should be very good records, or at least there were in past years, although those of BHT when they were in Rugby, might be difficult to find. He set about trying to locate old radar photographs, and came up with some of those DHT had described. He then asked about a specific one, and rather than writing a long story, DHT taped a verbal statement and sent him the tape. He was overjoyed, and his secretary transcribed it. After some corrections, this text was the result. (There are still some ink corrections).

A copy of the photograph in question is attached, and several other photographs relevant to the text are also added.

- (1) The Klystron developed by Prof. Oliphant at Birmingham University in parallel with the Cavity Magnetron (cut away to see the construction)
- (2) The version of radar set, in two parts as developed from the original, for the RAF as a Centimetre Height Finder. The Radar part on a sound locator type trailer
- (3) The inside of the Display Trailer of the CMH
- (4) The first model of the Army style GL3, with all the equipment on one trailer, specially designed by Tasker Co. Ltd. for stability close to AA guns and weather resistant
- (5) A line drawing of the cabin, transmitter cubicle, aerial system, and display unit of an advanced model of the GL3

There is a large mounted photograph of the original equipment (photo 1) in the Radar Archive. Ask the Archivist to view.

Later there will be a fuller text on the development of GL3 in the Archive.

(92) Series listing of ADEE/ ADRDEIRRDE. Official technical photographs

The official Establishment photographer had control over all photographic operations up to mid-1941, when photography and data collection became part of experimenting and research, and although he protested against not being involved the lab workers won the day. It had become obvious that he treated ALL photography as information storage, and could not understand that, for instance, photographing a trace on an oscilloscope did not require a detailed photograph of the whole piece of equipment, but indeed required no external light. In later years, he was called upon along with many others to help in a crucial measurement on a series of plan position cathode ray tubes. He had rigged up two flood lights to illuminate his tube, and was very surprised, after we had removed his lights, that there actually were the required pictures on his photos, from the traces themselves. However on record photography, he was superb.

The lists appear to start in around September 1940, with an R as the initial denoting letter. There must have been photography used at Biggin Hill, the home of ADEE from 1922 to September 1939, and it is possible that there was no photographic base at Christchurch until a Studio was built in the Drawing Office in mid-1940. DHT had seen some copies which appear to have been made at Biggin Hill in the mid-1930s, but had no idea of the initial letter, but might have expected L, (Light), for the Searchlight Section and S for the Sound-locator Section.

The photographer swore on the superiority of glass plates over film, and used it as long as he could persuade Ilford to provide it. This finally came to an end in 1944, when glass became scarce due to energy shortage in the mid war period.

In general record photographs could be ordered to be taken at 6 to 8 hours notice other than for difficult pieces of equipment. DHT remembered one SCIENTIST who wanted a photo of the INSIDE of an almost closed box, which was difficult until a series of mirrors were installed in the box, visible through a small hole, solved the problem although the result required some careful study to determine what was what. There was a separate cine film processing lab in the charge of one of the scientific staff, and several specialist units for particular equipments. DHT for instance was using a high speed 'continuous' run system to photograph the amplitude of 1 microsecond pulses, at 400 up to 100 pulses per second, using 100yard lengths of X-ray film on 35 mm wide paper tape and requiring development in special solutions.

The Photographer kept a running log of all his photographs, but only by a serial number without any mention of the requisitioner's name or the equipment name. All copy transactions were conducted in his number and the requisitioner had to remember when asking for the photograph to be taken, to order a copy of ALL the photos involved, so that he had the numbers for any future copies! However, the photographer kept copies of all photos, but not indexed other than by his number. In about 1948, after some difficulties in identifying subjects, all these copy photographs were put in a series of albums (along with Security classifications and the albums were taken over by the RRDE Library. When in 1952/3, TRE and RRDE joined forces, the albums went to the TRE Library. However some 5 years later, when the RRDE photo unit finally joined with the TRE unit (the delay in moving often depended on space at the TRE site and priorities. Photographic and Drawing Office facilities were low priority), the TRE photographer decided unilaterally that he no longer required the RRDE negatives, and started a mass destruction. Subsequently, copies of older photographs depended on making new copies of the copy in the albums. At some point, by accident, Mr Colchester, the Patent Officer, saw piles of trays holding thousands of glass plates in a corridor and on enquiry, was horrified to find they were to be destroyed, and he intervened

and took them over, and subsequently had them taken to the Imperial War Museum. DHT believed that many of these could be Biggin Hill photos, since he described some as old sound locators. No identification went to IWM. DHT did contact them once, and they admitted to having thousands of glass plates from TRE but admitted also that they had no idea where they were in a storage cellar!

The next catastrophe occurred when a security officer on a routine visit to the library, discovered these albums had security classifications on the copies. The librarian pointed out that these were years out of date, and that almost all documents of the war years were declassified in bulk in 1945/6. He wasn't impressed and started a systematic destruction of all copies with classifications. The final straw was when the Establishment was being prepared for QinetiQ to take over, and refused to take over anything smelling historical, and the library started to distribute some of the documents to other places. And most of the rest were destroyed.

However, as a regular user of the library and in particular the photo albums, to assist illustration of papers and lectures, DHT had recognised the lack of identifications, as early as 1975, and when available up to retirement, had started at the beginning, making a subject index against the photographers number. Even at that time, there were many gaps in the albums which he never solved, but the librarian supported him very well and on retirement, rather than go into the library to work, he was allowed to 'borrow' the albums and produce the lists at home. Unfortunately, there was no set listing paper to use, and the lists were drawn up on sheets, and in manifold books, where the top copy went to the library and the copy was a carbon copy in the book. DHT kept these entries, although their use was limited in the absence of negatives or copies! However, he was approached twice by outsiders who had copies of some photos and wanted identification, and this was possible in all cases, and once by somebody wanting to know where they could find a particular equipment photo, and he was able to give him numbers and he kept a watching at flea markets and the like in case 'something turned up'. The Archivist at Sheffield was certainly anxious to take them over.

A last point on this. The original intention was that the Establishment library would digitise the entries and keep them on the Establishment Computer, and other parties could have disks. None of that happened after staff cuts intervened.

(93) (TSM 1) Trevor Simpson Moss, 1921-1996

It is appropriate that this introduction should start with the existing obituaries for Trevor Moss, since between them, virtually all is said of his Scientific work. These obituaries are appended to this and consist of one which appeared in 'InfraRed Physics and Technology' Vol.35 No.1, and the other, (written by D.H.T.), in Physics World, Vol.9. No.6. Copies of the original publications are in File 93 (TSM 2)

It will be seen that there is no mention of Trevor's work having any connection with Radar, which may seem strange, since he spent a considerable time at the Telecommunications Research Establishment. The connection is not generally known. He did in fact start his time at TRE, in the group under F.E. Jones, working on radar jamming and 'Spoofing'; but was moved to Infra-Red immediately after the D-day landings.

Most of the Wartime radars operated in the VHF or UHF bands, and by the end of the war, had been stretched down to 0.5cms wavelength, and there was active speculation as to whether there was any possibility of getting sufficient power at Infra-Red frequencies to make a viable radar, and whether a sufficiently sensitive detector could be devised to pick out returned signal from aircraft. The workers turned to the new technology of Semi-Conductors and whilst detectors were devised using various semi-conductor materials, the transmitter question remained unsolved until the carbon dioxide laser was introduced in later years.

Trevor however had made several discoveries more to do with semi-conductor improvements and the laws concerning these, such as the Moss Rule and the Burstein-Moss Effect. These and other researches paved the way for others to introduce successful light emitting diodes, which firstly and appropriately, replaced filament lamps as indicators on scientific, electronic and electrical equipment, and were subsequently used for the same purposes on domestic equipment and in the automotive industry.

During this early period of Trevor's work, there was little direct connection with R.R.D.E and TRE and consequently DHT and TSM had not met. The connection came however by the meeting of Trevor's girlfriend, Miss Audrey Nelson, and Mrs. Margaret Tomlin. The former had joined A.D.R.D.E. in 1944, and not being of a particularly technical mind, but interested in history and books, became an assistant in the Library, under Miss Dorothy Harper, the Chief Librarian, and Miss Muriel Lewis, her deputy. Late in 1944, Miss Harper (who had been seconded to the Establishment by Courtaulds at the outbreak of the war), returned to her peacetime post with the firm and shortly afterwards, Miss Lewis returned to her teaching post in S. Wales, leaving junior staff, including Audrey Nelson in charge of the Library.

By mid-1944, it was generally considered that the war would be over by 1946 and there was a general move by many of the wartime staff to leave as soon as possible. Many had been seconded from other major firms, and a vast majority were graduates who had been directed into the Establishment (as had DHT in 1942) immediately after graduation. Many had hoped to go on to PhD, and as many as could moved away, to get into their universities before those in the Services were demobilised and used their priority to take up places in the universities.

Mrs Tomlin had been left at Christchurch, the previous home of ADRDE, when that Establishment had been evacuated to Malvern in May 1942, and was somewhat disillusioned since she had only weeks before transferred as a teacher from Leamington to Christchurch, having married only the previous Christmas, to be near to DHT. She wrote to the Chief Superintendent, John D. Cockcroft, offering her services, particularly if there was a mathematics department. She was immediately recruited and joined the Mathematics Group at Malvern. Hence the two ladies came to know each other, since MT frequented the Library only a few rooms away from her office. However, at the end of 1946, MT, now expecting her

first baby resigned and Audrey Nelson was again left in charge. (Another lady scientist from another group took over the Chief Librarian post).

Unfortunately Mrs T's baby arrived prematurely, in the midst of the fierce winter of 1947, and with breathing and feeding problems, he died of pneumonia at 12 days old. Over the following month, Audrey and Trevor were their constant props, spending most evenings at the Tomlin flat. Mrs T's doctor was urging her to drive her fears away and try for another baby, and later in the year was successful, but she would not take the step until they had agreed to move their home. They bought a house and moved in on Jan 1 1948, and the baby was born in March. They were to stay in that house for 55 years, although it had been intended to find a smaller house, since it was far too big. Audrey was a constant friend and supporter, and kept saying that they would love to find a house so that they could marry. MT and DHT talked the matter over and finally offered them two rooms, so long as they could furnish the bedroom (the spare room downstairs was already furnished). Audrey and Trevor fell on DHT and MTs' necks with joy, and were married 4 weeks later and moved in. So the connection between DHT and TSM was made, and although they moved to Cambridge in the autumn of 1950 and after he had gained his PhD only two years later, moved again to Farnborough, the two families saw each other at least once every 3 months, until around 1976 when TSM again came to Malvern as Deputy Director RRE. Both were godparents to Mrs T's second daughter Joan, born in 1952.

A TRIBUTE TO TREVOR MOSS

From *Infrared Phys. Technol.* Vol. 35 No. 1, 1994

Trevor Moss has been the Editor of *Infrared Physics* for nearly 33 years, being responsible, as Co-Editor, for launching the Journal in 1961. In 1973, he became Executive Editor and has continued in that role, to the enormous benefit of our readers, for the following 20 years. With the turn of the year Trevor has decided to retire. The quality of *Infrared Physics* is clearly attributable to the professionalism and enormous skill which Trevor has applied to his task, and this is undoubtedly the product of his exceptional talents as a scientist and a manager.

Trevor was born on 28 January 1921 and lived in Uttoxeter, attending Alleynes Grammar School. In 1939 he went to Downing College Cambridge, where he obtained a First Class BA Honours degree in Mechanical Sciences in 2 years. At the age of 20, he joined the Royal Aircraft Establishment at Farnborough, where he undertook practical investigations of radar, including operational flying and tests of the technology during the war. In 1944 he moved to the Telecommunications Research Establishment at Malvern, where he became engaged on the now well-known R.V. Jones type of activity. During the war he gained various honorary commissions with the RAF and took part as a Flying Officer in the invasion of France.

After the war Trevor returned to Cambridge for his PhD, which he gained in 2 years in 1951. His thesis formed the basis of his first book, *Photo-conductivity of the Elements*, which is still regarded as the definitive text on the subject. He returned to RAE Farnborough in 1953 where he specifically insisted on following a scientific career, leading to his appointment as an Individual Merit Senior Principal Scientific Officer in 1958. He accepted promotion to Head of Radio Department at RAE in 1968. In 1978, he became Deputy Director at RSRE Malvern, where he remained until his retirement from Government Service in 1981.

Amongst his numerous publications was his second book, *Optical Properties of Semiconductors* (1961); his third book, *Semiconductor Opto-Electronics*; and, as Editor, the 4-volume, *Handbook of Semiconductors* (1982-84) which he has recently updated and extended to 5 volumes. From 1981 to 1990 he was additionally editor of *Progress in Quantum Electronics*.

His contribution to innovative research has covered an extensive range of scientific activities, but with emphasis in the fields of semiconductors, infrared, opto-electronics and in pioneering some of the early work on lasers. He has numerous scientific achievements and discoveries, including the Burstein-Moss effect and Moss' Rule (concerned with semiconductor absorption and refractive indices, respectively). He received many awards and citations for his outstanding accomplishments, including being elected Fellow of the Physical Society, award of the Max-Born Medal by the U.K. and German Physical Societies, the award of ScD by Cambridge University, and the Denis Gabor award from the SPIE in U.S.A.

Both the publishers and readers of *Infrared Physics* express our thanks to Trevor for his major contribution to this Journal and wish him a long and happy retirement.

G. BURRELL
Logica

people

Trevor Simpson Moss 1921-96

Donald Tomlin

Trevor Moss, FInstP, a leading authority on the optical properties of semiconductors, died in Worcester on 23 March 1996 after a stroke and almost two months in hospital.

Moss was born at Bugwalton, Cheshire, on 28 January 1921 and was educated at Alleynes Grammar School. He entered Downing College, Cambridge, in 1939, but was almost prevented from doing so by not having studied Latin. This he remedied by taking a six month course that led to his gaining the School Certificate. At Cambridge he received his BA in engineering sciences with first class honours after only two years.

He joined the Royal Aircraft Establishment (RAE) in Farnborough in 1941, and then moved to

the Telecommunications Research Establishment (TRE) at Malvern, where he worked on electronic countermeasures with Robin Smith, Robert Cockburn, Frank Jones, Martin Ryle, Ted Cooke-Yarborough and many others.

During this period he was posted as a civilian in uniform, with honorary commissions as a flight lieutenant, in the Royal Air Force as a result of the invasions of North Africa, Italy, Normandy and southern France. In each case he acted as a consultant, directing the countermeasures warfare. In 1945 he was again in uniform, this time as part of a team investigating Germany's radar installations. While he was inspecting a "Mammuth" installation on an island off Denmark,

Moss and two technical sergeants found themselves accepting the surrender of a German contingent that had been bypassed and left stranded.

Back at TRE after the war, Moss started on the research that was to fill most of his remaining working life: the optical and infrared properties of materials, particularly semiconductors. This area was beginning to interest defence scientists because of proposals for heat-seeking missiles and ways to detect heat radiation from engines. He was never directly involved in these projects, but was interested in the properties of materials on which they relied.

In 1948, after marrying his wife, Audrey, who worked in the library of the Radar Research and Development Establishment at Malvern, he returned to Cambridge to do a PhD on semiconductors under the supervision of Charles Oatley (who died in March of this year, 12 days before Moss). His thesis, which he pre-

sented after only two years, was later used as the basis for *Photoconductivity in the Elements* (1952) - one of the definitive books on the optical properties of the elements. This book is still in demand, and has been the basis for countless works by other scientists.

Moss returned to TRE in 1950 to continue the same type of work, before the project was transferred to the RAE in 1953. Here he led an experimental team at Ambarrow Court, an outstation of the RAE, where his team worked without serious administrative responsibilities. In 1958 he was promoted to senior principal scientific officer.

Moss's research has contributed much to our understanding and applications of infrared and photoconductivity of semiconductor compounds. His achievements include the first measurement of photoconductivity in elements and compounds such as indium antimonide (InSb) and lead selenide (PbSe),

the discovery of the photo-electromagnetic effect (known as the Moss-Pincher-Woodward effect), and the first observation of the Kranz-Keldysh effect of the shift of an absorption edge in an electric field.

One of his greater discoveries was to recognize the relationship between refractive index and the energy gap in a semiconductor, known as the Moss rule. At the same time he observed the shift of an optical absorption edge with carrier concentration, known as the Burstein-Moss effect. He then studied the relationship between refractive index and the absorption of solids, and showed how plasma edge reflection could accurately determine effective masses and carrier relaxation times, without having to use electrical connections.

Several years before the first semiconductor laser was made he had noted the highly efficient emission from InSb, which was caused by the recombination of carriers. He made the first detection of Fresnel drag due to moving electrons in a solid. A surprise discovery came when he determined the refractive index of tellurium, which was greater than any previously known. One outcome of his work on infrared photoconductivity was the practical realization (by others) of

the now ubiquitous infrared photodetector. In 1967 he was granted a provisional patent for a highly efficient cathode-ray tube that used a gallium arsenide emitter, rather than a heater, to illuminate the photocathode.

In 1968 he was talked into the post of head of the radio department of RAE, which he reluctantly accepted. Ten years later he was back at Malvern as deputy director, where he coordinated the transfer of the Signals Research and Development Establishment (Christchurch) and the Services Electronic Research Laboratories (Baldock) to Malvern. They merged with the Royal Radar Establishment, to form the Royal Signals and Radar Establishment - the UK's main electronics laboratory.

As this task neared its end, Moss suffered a severe heart attack. Although he slowly recovered, he retired from the scientific civil service in 1980. However, he continued writing books and editing journals, including *Infrared Physics*, which he had helped to found in 1961. He also edited the four-volume *Handbook of Semiconductors* between 1982 and 1984.

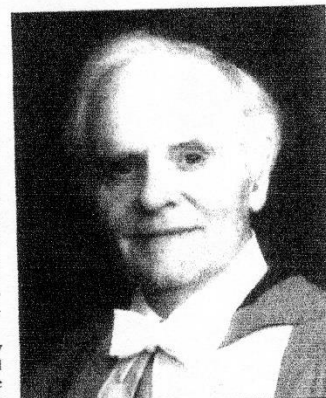
For many years, both while working and in retirement, Moss was in demand as a speaker, and he was

well known for his humorous after-dinner speeches. In 1978 he was awarded the Max Born medal from the German Physical Society and the Institute of Physics, and he also received the Denis Gabor award from the International Society for Optical Engineers in 1988.

Privately, Moss was proud to have featured in Debrett's *Distinguished People of the World* (1989) and the *Dictionary of International Biography* (1993), and to be one of the first Britons to appear in *Who's Who in the World*. It is a tribute to his thoroughness in keeping records that this appreciation has been compiled with the help of some notes he left behind.

Trevor Moss was a deeply religious man and he loved classical music, including the oratorios. This was to be one of his mainstays after retiring, while his Christian faith sustained him during his illnesses. He was also a keen woodworker, and in retirement he became proficient in woodturning, making bobbins for his wife's lace-making activities. Another abiding interest was the unravelling of his family genealogy, which exercised his great logical

abilities and which he pursued until his stroke. He also never forgot his early encounter with Latin, and used



Trevor Simpson Moss - optical leader

this knowledge effectively when solving crosswords.

Trevor is survived by his wife.

Donald Tomlin designed, developed and deployed defensive ground radar for the Army and the Royal Air Force. He retired in 1979.

(93) (TSM 2) Publications with information concerning Dr.T.S.Moss

Note. These are specific publications with information about TSM and his career and death. They are not the only ones with such information, but the residue after several years after his death, others having been destroyed or given to specific persons or bodies by Mrs. Moss.

DHT

- 1) RAE News.Vo1.28 No.6. June 1976 Page 5 Trevor Moss receives the Max Born Award
- 2) RAE News Vol 31 No 11 November 1978 Page 4 Trevor Moss is promoted to Deputy Director, at The Royal Radar Establishment, Malvern
- 3) Shell Aviation News No 378 Undated, but from the Index at the end of the publication, December 1969, Page 6 The systems approach to Civil Avionics. R.S. Lees, G.R. Robinson and Dr. T.S. Moss, Royal Aircraft Establishment, Farnborough
- 4) Infra-Red Physics & Technology Vol 35 No 1 (Dated for February 1994 (but this must be a misprint, repeated throughout the publication, since the Obituary for T.S. Moss, as originally provided, shows the death of Dr. T.S. Moss was 23 March 1996) Page V A Tribute to Trevor Moss. G. Burrell, Logica
- 5) Physics World Vol 9 No 6 June 1996 Page 59/61 Trevor Simpson Moss 1921-96

(93) (TSM 3) Semi-conductors in optical studies

A small collection of papers involving some of Dr. Moss's interests

- 1) Reprint from 'Nature', vol.161 p.244 Feb 14. Spectral Response of Lead Selenide. T.S. Moss & R.F. Chasmar, Physics Dept T.R.E. Great Malvern
- 2) Experimental Studies of some Opto-Electronic Properties of Thin Films of Galena. N.M. Ravindra & V.K. Srivastava, Dept of Physics, University of Roorkee, 247672 India
- 3) Recombination Theory for Indium Arsenide. T.S. Moss, Radio Department R.A.E. Farnborough, Hants. Proc. Phys. Soc. E. Vol LXIX P661 1956
- 4) Cyclotron Resonance in $Pb_{1-x}Sn_xTe$. E. Ellis & T.S. Moss, R.A.E. Farnborough
Dedicated to Prof.Dr ... Dr. h.c. P.Gorlich on the occasion of his 65th Birthday
- 5) Quantum Efficiency and Responsivity of InSb Photodiodes Utilising the Moss Burstein Effect. Zoran Diuric, Branco Livada, Vesna Jovic, Miloliub Smiliank, Milan Matic & Zarco Lazic, Inst of Chemistry, Technology & Metallurgy, OOUR Inst. for Microelectronic Technologies & Single Crystals, Belgrade, Yugoslavia. InfraRed Phys.Vol.29 No. 1 pp 1-7
- 6) Second Copy of (5)

(93) (TSM 4) Photo-Electromagnetic Detectors & Optical Dielectric Constants

- 1) Theory of Intensity Dependence of Refractive Index, based on the Burstein-Moss effect. T.S. Moss RSRE Malvern 1980. Typed copy as circulated for comment pre-publication
- 2) Analysis of the Moss and Ravindra Relation. R.R. Reddy & S. Anjaneyulu, Dept of Physics Sri Krishnadevaraya University, Anantapur, India
- 3) Opto-Electronics. T.S. Moss. Farnborough. Physikalische Blatter, 1975
- 4) Theory of Intensity Dependence of Refractive Index. T.S. Moss, RSRE Malvern. Phys. Sta. Sol. (b) 101.555 1980
- 5) Second copy of (4) above
- 6) Refractive Indices, Electronic Polarizabilities and Dielectric Constants of Alkali Halides. R.R. Reddy & S. Anjaneyulu, Sri Krishnadevaraya University, Anantapur, India
- 7) Variation of Refractive Index and energy gap in Semiconductors. N.M. Ravindra & V.K. Srivastava, Physics Dept, University of Roorkee, Roorkee, India. Typed copy, marked Received in final form 29/11/79, Sent to IRP 6.2.79. Published 19. 603, 1979

(93) (TSM 5) Photo-Electric Detectors

- 1) On the Performance of non-cooled (In,As)Sb Photo-Electromagnetic detectors for 10 Micrometreradiation. K. Jozwikovski, Z. Orman, A. Rogalski, Institute of Technical Physics, Warsaw
- 2) Diluted Magnetic Semiconductors based on II-VI Compounds for Photovoltaic Detector applications. Janusz M. Pawlikowski, Inst. of Physics, TUW, Wyspianskiego 27 50-370 Wroclaw, Poland. Infra-Red Physics, Vol. 30 No. 4 P295-305. 1990. Rcd. 17.2.1990
- 3) Internal Photo-Effects in Graded Gap Semiconductors-I. Excess-Carrier Distribution. Janusz M. Pawlikowski, Institute of Physics, Technical University of Wroclaw 50-370 Wroclaw St. Wyspianskiego. Infrared Physics Vol. 20. p 257-269. Rcd. 2.1.1980. (Includes handwritten greetings to T.S. Moss)
- 4) Energy Gap and Optical Dielectric Constant Of $Pb_{(1-x)}Cd_xSe$ films. M. Baleva, M. Maksimov & M. Sendova. Faculty of Physics, University of Sofia.1126 Sofia, Bulgaria
- 5) The Moss Rule and the Influence of Doping on the Optical Dielectric Constant of semiconductors -11. H. Finkenrath, Institut fur Angewandte Physik Technische Flochschule Darmstadt. D6100, Darmstadt, F.R.G.

(93) (TSM 6) Proceedings of Photo-Conductivity Conferences (Abridged) 1954 &1961,
Proc. Phys. Soc. {Faraday Effect (paper) 1964}

- 1) This review of the book containing the papers and rather fuller discussion at the 1954 Conference on Photoconductivity. Written by T.S. Moss (Typed copy). Book published in 1956
- 2) Review of the Conference on Photoconductivity held at Cornell University Aug 1961 Published in Br. Journ. of Applied Physics 1 Jan 1962 (Reprint) Written by T.S. Moss 26 Sept 1961
- 3) The infra-Red Faraday Effect in n-type AlSb and GaP and in undoped GaP. T.S. Moss and B. Ellis, RAE Farnborough. Reprinted from Proc. of the Physical Society 1964

(93) (TSM 7) A note on Appendicitis in Japanese (un-translated at source)

- 1) During a conference on Semiconductors in Tokyo, Japan, T.S. Moss who was a chief speaker was taken ill with appendicitis, was taken immediately to hospital and an operation carried out. He was discharged 4 days later and flown immediately back to UK, all free of cost, as an Honoured Guest of Japan. A short time afterwards, this paper appeared at Trevor's home from the Senior MO who had carried out the operation!

DHT thought it sufficiently important to include it in the Archive even though it has nothing to do with Semiconductors. Note that some of the captions for the photographs and the tables are in English!

Pages work right to left

(93) (TSM 8) Infra-red radiation from the sun

- 1) An account of an experimental investigation of the Infrared spectral response of the Sun. T.S. Moss, RAE, Farnborough. Reprinted from 'Iris' Vol. 5 No.1 1960

(93) (TSM 9) Sundry correspondence re Infra-Red.

- 1) Constitution of 'Infrared Physics' Board
- 2a) Letter to Prof Finkenrath
- 2b) Note to TSM from Prof Finkenrath enclosing a copy of his paper (in German) 'Über den Einfluss den Bandabstandes und der Bänderbesetzung auf die Dielektrizitätskonstante von Halbleitern'. Zeitschrift für Naturforschung Band 19a Heft 6 1964. Manuscript note added 'Died 15 July 1988'
- 3a) Letter attached to (3b)
- 3b) To T.S. Moss 26.6.1987 re a review in Phys Stat Sol(b) 131 re relationship between optical energy gap, refractive index and optical dielectric constant.
3a) is a reply from TSM dated 7 July 1987
- 4) Copy of front cover of 'Infrared Physics' Vol. 1 No.1 March 1961

(93) (TSM 10)

Photographs

Some of these photographs are of staff retirements from the Radio Dept. at RAE. Some are of mass gatherings at various Semiconductor and Optoelectronics Conferences.

The various specialised aircraft used at RAE for studies are featured and some of the staff along with T.S. Moss responsible for some experiments also appear. Special occasions such as the opening of the new building at RRE by the Duke of Kent, to house the staff from SRDE (Christchurch) and SERL (Baldock) as they came to Malvern after the three Establishments were amalgamated as RSRE in 1978/9 or the presentation of the Max Born Prize at Munich in 1975. The completion of the 'Noise' facility is also featured.

(94)

This file relates to the Radar equipment GL3 or by its full title, RADAR A.A. No 3 Mk 2, an equipment described in 1945 immediately after the end of the European War as the 'Wartime Workhorse of the Army' by General Pyle, wartime head of the Anti-aircraft Brigade.

The significance of this will become clear as the file progresses.

The main file will be broken down into discrete subject files, which will be identified in the same manner as those in earlier sequences where sub-numbers have been used to identify the individual files for instance:

File 94 (GL.RADAR 17) Meteorological systems (fictitious example)

(94) (GL RADAR 1) History

In the 1930s period, the design of aircraft for civil purposes was progressing rapidly and air routes to distant places were becoming established. In some localised wars, aircraft were used for some specific purposes such as visual spotting of troop movements. They had been used in the First World War by the British and German Armies, particularly for giving directional information to gun batteries to direct gunfire on to specific targets, and these activities were frequently the trigger for personal attacks by pilots on one side attacking aircraft (and pilots) on the other side. It was realised by the authorities that with improved aircraft design and continuously increased flying speeds, the potential of aircraft to become a significant factor in both attack and defence were increasing in importance.

However there were some important voices, following personal studies, where the conclusion was drawn that 'The (attacking) aircraft will always get through', and in the economic climate of the 1930s nothing was done. However in the Air Ministry, there were some who considered this defeatist attitude was unjustified, without more detailed study. By 1934, there was in fact a research station at Slough in the UK, where every day radio signals were directed upwards into the sky, to determine the state of what were called 'Ionised Layers', the importance of which were recognised as controlling the ability of radio stations (commercial and Naval) to communicate around the world. This ability was of importance to Shipping Companies, in being able to get information about their ships on the oceans. The Admiralty was interested for similar reasons. The importance was the fact that the distance away from a transmitter was determined by the layers' ability to reflect radio signals back to earth, when they would otherwise be lost into space. The density and extent of the layers determined how far and how effectively signals could be spread across the world via the layers.

A powerful scientific committee set up in December 1934 under the chairmanship of Mr Tizard (another Scientist of note) was given the task of studying all the possible means of defence against bombing from the air. These included Very hot heat beams and (the subject of many far-fetched science fiction stories) radio waves. It was not felt capable of answering some of these questions, and turned to Mr Watson Watt, the Director of the Slough Radio Research Station for advice. He quickly came back with the answer that even if all the radio power emitted from ALL the transmitters in the world could be harnessed and their radiation put into a single beam, it would not be sufficiently powerful to kill a man at say 2000 feet away (a distance equal to the height at which most aircraft flew). In this answer was some information provided by Prof. Hill, a Member of the Committee who as a biologist, had calculated the amount of power which would be required to kill a man, or even inconvenience him.

However, Watson Watt added a note at the end of his answer, to the effect that 'It might be possible to detect the presence of aircraft by radio means'. The Secretary of the Committee, Mr Rowe, reacted to this immediately and called on Watson Watt to elucidate. Mr Rowe was a scientist and at the time was secretary to the Director of Research in the Air Ministry and it was he who drew his Director's attention to the total lack of preparedness against attack, causing the Committee to be set up. It is sufficient to say here, that a demonstration near Daventry was set up where as conjectured, the presence of an aircraft was demonstrated to Mr. Rowe, representing in this case, the Air Ministry (no other Air Ministry or RAF personnel were present at the demonstration). Signals from the BBC Daventry Transmitter on 49 metres wavelength were used for the experiment, Mr Rowe knew sufficient to prevent him from asking, 'Yes, but WHERE is it?'. The simple answer reported to the RAF and Air Ministry that the aircraft had been detected as it flew at right angles to the direction from Daventry, and forward of the site of the detector, was sufficient to release a significant

amount of money to allow of further research (initially at Shoeburyness, an island off East Anglia).

Work at Shoeburyness produced positive results, i.e. aircraft could not only be detected, but using other techniques (already in use at Slough), gave the distance from the transmitter to the aircraft. This technique, at Slough, was used to determine the height of the ionised layers above the earth's surface and was simply modified to suit the much smaller distances involved.

More recent studies have shown that there is a likelihood that Watson Watt and his assistant at Slough, Mr. Arnold ('Skip') Wilkins had seen radio signals returned from aircraft on the ionograms at Slough. A picture published in an article in a technical magazine shortly before 1980, showed in addition to the normal signals from the ionosphere, a horizontal line, just above the horizontal baseline (representing frequency) with the annotation, 'Aircraft leaving Heston (or Croydon)' (the author is uncertain at this time).

However, later experiments were carried out at much higher frequencies. The first RAF aircraft location radars operated in the band around 30 Megahertz, those for the army settled in the 55 to 75 MHz band, and both services migrated to 200 MHz, for both airborne radars and defence radars. These frequencies however were not high enough to make narrow beams satisfactorily, a property necessary to pinpoint the true position of targets. The Services and their scientists were desperate to find thermionic valves which would generate sufficient power on frequencies in the low centimetric bands. The Royal Navy went part way when they moved to the 600 MHz band for many of their radars, and the Army started exploring this band. The General Electric Co in UK and the Naval Valve Development group did in fact gradually push up the power available on this band, and the Army group benefitted from this development.

In late 1939, however, the Director of Scientific Research at the Admiralty (DRS) placed a development contract with Birmingham University Physics Department to study means of producing power at around 10cms, (3000 MHz) and this surprisingly was successful when Randall and Boot produced some 10Kw from a new design of valve, in March 1940. The valve was a multi-cavity valve based on a diode with central filament or cathode surrounded by a block of copper with an even number of holes accurately located at equal spacings around the cathode, and slots connecting the central cylinder to each 'cavity'. The experimental valve was water cooled and was pumped to a high vacuum, and indeed looked crude. However IT DID PRODUCE POWER. GEC were given the task of making the crude valve into a reproducible item. Available power steadily grew over the years, and by May 1941 100Kw (pulsed) was normal and by May, around 200Kw.

The British Thomson Houston Co were given a contract in October 1941 to develop a new radar for the Army, as a means of providing good following information from aircraft to predictors to enable targets to be engaged and that was the beginning of what was to become known as GL3.

It is necessary here to digress somewhat, because an Army (more correctly, Ministry of Supply research group working for the Army), had developed a radar in 1938 operating on the 55 to 75 MHz band which could locate and follow targets with an accuracy of around 1 to 2 degrees in bearing and about twice that in elevation, and range accuracy of about 50 yards. As the best available at the time, this went into production as GL1, (Radar AA No1 Mk1 in vocabulary nomenclature) and around 200 were available by the start of the war in September 1939. In 1940 work started on an improved version, whereby the bearing and elevation accuracy improved by a factor of about 3, and the range by 2, by 1941. This improved

equipment was designated as GL2, (Radar AA No1 Mk2). The AA No1 signified that it was the first type of Army Radar operating in the 60MHz band and the Mk1 and 2 that they were the first and second models of that type. The simplified designation GL1 and GL2 signified that they were the first and second versions of AA radar for the Army.

This was the background to the later equipment GL3 starting in October 1940, with a target of bearing and elevation accuracy on a 300 mph target of 10 to 15 minutes of arc and 10 yards in range up to 24,000 yards, increased in 1941 to 36000 yards.

In early 1940, before the Cavity Magnetron was produced, the engineers and scientists at Birmingham University Physics Dept. set out to build what was to be the first radar operating in the 10cm band. In 1939, Prof Oliphant had visited the USA and went to the laboratories of the Varian Brothers, who had been reported to have built high power valves for use as both oscillators and amplifiers on what was called, the Klystron principle. Oliphant was interested because a new cyclotron was being built at the Physics Lab, and would require valves for the control oscillators, and since there was talk of developments in the cyclotrons which could require high power variable frequency oscillators, he wanted to explore their potential. In a Klystron, a beam of electrons are passed through a central hole on a circular cavity (rhumbatron) often called a 'doughnut'. He could not obtain a model, but did bring back typical drawings of a valve, and back at Birmingham, realised that his cyclotron was not going to be set to work until after the war. He knew of the call for high power valves for 10cms, and designed a valve on the klystron principle for a nominal 10cm wavelength. All this was going on in parallel with the initial work by Boot and Randall, and in fact worked before the Cavity Magnetron was working.

Not many people knew of this work, but of course it was promptly classified as Secret, but within the University work continued. The scientists (under Oliphant) decided to build a radar set using the Klystron, and this was working by February 1940. Some interesting principles were embodied. Oliphant during testing of his klystron, found that the generated frequency was voltage dependent, within the bandwidth of the rhumbatron. He realised that this COULD solve the problem of not only having a high power valve as a transmitter, but also have a local oscillator of low power to detect return signals, by the heterodyne principle. His radar embodied these systems. He was lucky in his valve behaving benignly 45mcs being the difference chosen from his transmitter frequency. Thus his power system produced a shaped 1-microsecond high power 10kV(?) pulse for the transmit phase and then dropped to a constant 200 volts approx. as a local oscillator.

This radar set was demonstrated to BTH after an inaugural meeting of Ministry of Supply and B.T.H. Co in October 1940, when a contract was being placed with BTH for the development of a new radar on 10cms, for the Army. There were complications here because although Oliphant's set worked adequately for demonstration purposes, a lot of the electrical parts were simply spread out on the base of a lorry, with a sound locator turning system in the centre, with two 6ft diameter parabolic mirrors mounted on it. The equipment was totally unprotected, and the only concession to the weather was a large tarpaulin which could be dragged over the equipment. The Ministry conceded that BTH should have a proper model which BTH were to build. Since this was the first radar set to be built by BTH, it was appropriately called 'Set For Oliphant' (SFO). It is recorded that thereafter all orders to provide equipment for BTH radars were recorded as 'SFO (number)' i.e. 'SFO .. 257' for example.

One thing however that the Birmingham staff did, which showed the potential of a 10cm radar was the plotting of the barrage balloon locations in the central and eastern sectors of Birmingham.

This new set was never delivered to Birmingham, but came to ADRDE (then at Christchurch), when it was completed and had been put through trials by May 30 1942. Just before the set was delivered, the system for producing the Long local oscillator signal was removed along with the klystron because the frequency of operation was too erratic and took a technician most of his time just tweeking it. (NOT suitable for Service use). Oliphant still believed that it could be made to work, but the small Reflex Klystron devised by Dr. Sutton was so much simpler and stable. {DHT was delighted, because he was to look after and operate the set for over a year, doing all sorts of trials with it (to be detailed later)}

Another demonstration Set was built by the staff of AMRE, had arrived at Swanage in mid-1940 after a devastating short stay at Dundee University following the RAF taking over Bawdsey Manor as an operational site. Their arrival at Swanage almost coincided with the first demonstration of the magnetron at Birmingham. They built a simple system to demonstrate the principles, and this, after testing, was toured round other Establishments with an interest, such as ADEE at Christchurch in early 1941, having been to the Naval Signals School, to BTH at Rugby, Metro Vickers at Trafford Park and GEC Research Labs.

The equipment, known as the 'TRE Trailer', was housed in a respectable cabin and had two paraboloids on the roof mounted side by side on a gimbal mounting system. There was no power turning system, and the aerial position was controlled by strings which went up through the roof, and it really was a bit difficult. 'Ah, a signal', 'Round left a bit', 'A bit more', 'Up a bit', 'Too far', 'Hold it', etc. The transmitter was in a small rack and the receiver with a 4 inch oscilloscope in a second rack. It had been used at Swanage by Prof Lovell, to try to determine the shape of the return signals from the targets (all friendly and cooperative aircraft). More on Prof Lovell's experiments later.

(94) (GLIII Subfile 1)

Early History. Purpose; The Tizard Committee of 1934: Early experiments; The Klystron:
The Magnetron: TRE Trailer: BTH Contract 1940: First BTH 10cm radar equipment 1941:
Final Design objectives

(95) German Searchlights; Heinrich Beck (Institute)

Heinrich Beck was a researcher in the early days of the 20th century, working on improvements to German Searchlights, specialising in the electric arc lights.

In his memory, an Institute has been set up, The Heinrich Beck Institut in Meiningen. A member of the staff is his great grandson, Tilmann Beck, who in early December 2009 came to England to discover equivalent work in England and to record Memories of Searchlights in this country. He was referred to DHT, and came to Malvern. Since, as far as is known, there were no searchlight design workers still around in 2009, DHT was fortunate to have talked to 'Pony' Moore and other early workers at ADEE, extensively on the subject and the early history of the Searchlight Establishment in the 1920s and its predecessors the Searchlight Experimental Group in 1917 to 1922, and the London Electrical Engineers from their inception around 1898, later becoming a battalion in the Territorial Army and serving in the searchlight Forts along the River Thames during the First World War.

It was hoped that a copy of the recorded interview would be made available to DHT to be included in the Radar Archive, since the interview included the development of the Searchlight Control Radars in England to assist the searchlights to locate the targets and to track them from 1940.

Tilmann Beck left DHT with a copy of a paper about Heinrich Beck, which is the subject of this File.

(96) Book 'One Story of Radar'

The Content of this file is solely a copy of a book 'One Story of Radar' written towards the end of the 1939-45 war, by Mr. A.P. Rowe, the Chief Superintendent of TRE (Telecommunications Research Establishment), which was responsible for the development of Radar and associated equipment for the RAF, whether airborne or surface located for support of the RAF, and to a minor extent, the Navy. It was written to make the point that TRE was the superior radar development establishment in the UK, whereas in fact Ministers and Leading Officers of the Services considered that all three Services were well supported with radars specifically designed around the prevailing requirements of all the services. It does however highlight the problems encountered by all the designers, all working at the far front of knowledge and technical capabilities of the time.

One thing it does however is to highlight the necessity for stability of the workforce and their environment, and the utter loss of energy and interest in their jobs and faith in their superior management when they are forcibly moved to new locations. (TRE suffered 4 moves in 6 years, viz. Orford Ness to Bawdsey (1936), Bawdsey to Dundee (Sept 1939), Dundee to Swanage (1940), Swanage to Malvern (1942). Rowe capitalised somewhat on these moves, particularly the move from Swanage to Malvern by describing it (theoretically) in somewhat minute detail, as a result of which a commercial film was made in 1946, following his details (School for Secrets) which was a great success and popular! It did of course bring TRE to the public notice.

There is considerable trumpet blowing in many of the descriptions of the RAF equipment that TRE designed. Rowe himself acknowledges that he was an administrator, and had little knowledge of the technicalities involved.

(97) Correspondence between R.G. Stansfield (Member of the Operational Research Society) and DHT on the origin of Operational Research

Papers on O.R. (enclosures with letters)

One letter (draft only) in pencil manuscript. Last page missing

- (98) Pamphlet by the late Ernest Putley, 'Science comes to Malvern' and sub-titled 'TRE a story of Radar 1942 to 1953'

(99) 'The First Step' (SLI 19)

A mounted Print of a painting 'The First Step' by Roy Huxley

This painting depicts the first experiment in February 1935 to determine whether it was feasible to detect the presence of aircraft by radio, to satisfy the RAF hierarchy, and in particular, Sir Hugh Dowding, that money should be spent on the development of a radio detection system. Sir Hugh was at the time the Air Member for Research and Development.

The painting shows two people, the first almost certainly A.P. Rowe, who was observing the experiment on behalf of the Air Ministry. He was the Secretary to a Committee for the Scientific Study of Air Defence, and the second is almost certain to be Mr Watson Watt who was the Director of the Radio Research Station at Slough, who had proposed the experiment, and was present to see that all went well. (There had been no time to run any checks of the system). The only other person present was Mr Arnold Wilkins, deputy to Mr Watson Watt, who had devised the experiment and had constructed the equipment using apparatus from the Radio Research Station and was in charge of the demonstration. The driver of the vehicle shown had been sent away from the vicinity of the experiment. The picture shows the 2 aerials connected to the equipment in the van. On the horizon, some 14 miles away, left of centre, can be seen the transmitting aerials of the BBC Daventry radio station designated 'GSA' operating on 49 metres. Overhead is the Heyford Bomber used to simulate an attacking aircraft.

In fact there is a certain amount of artist's licence in the set-up, in that the Daventry Transmitter and its aerials were in a valley and deliberately not visible from the field in order to mitigate the direct ground wave.

The experiment produced a positive result, and set the seal on the enormous effort put into providing what was later called 'RADAR' in time to be operational before the War in 1939.

A much more detailed but simple description is given in 'The Birth of British RADAR' by Colin Latham and Ann Stobbs, published by Speedwell on behalf of DEHS. There is a copy in the Radar Archive at File 71.

D.H. Tomlin, May 2010

List of Photographs and other pictures & Descriptive Information

SLI 13 GL3/CMH Model A'0'

This was the very first Radar Equipment authorised to be built by a Commercial firm.

In August/September 1940, following the demonstration of the Cavity Magnetron at the Physics Dept of Birmingham University, but still whilst working on the development of twin cavity Klystrons, Prof Oliphant and his Birmingham Co-workers decided that it was necessary to build a radar working on approximately 10cms, to demonstrate the validity of what was postulated as the advantages of centimetric as against metric wavelengths. Using bits of Searchlight gear to provide mountings and turning gear, they built an equipment which was working by the end of August 1940. It used one of the Birmingham Klystrons, giving out around 10Kw in (approx.) 1 microsecond pulses. The Klystron was used as both the transmitter and the receiver local oscillator. There is no photograph or drawings of this set. A technician at the Physics Lab explained that it was built as a result of verbal instructions and literally, back of envelope sketches. This equipment had worked, and echoes from the Balloon Barrage had been seen, as well as from buildings. DHT had never found any evidence that echoes from aircraft had been seen.

At the beginning of October 1940, at a meeting called by the Ministry of Supply, held at Birmingham, the British Thompson Houston engineers were recommended to examine the set. It was described later to a meeting the following day:

'.. it consisted of two 6' mirrors, respectively with transmitter and reception aerials, mounted on a sound locator stand, and capable of rotation in vertical and horizontal planes. Between the mirror trunnions on the rotating table was mounted the electrical apparatus, information cathode ray tubes and operating switches and wheels. The whole was mounted on a low slung lorry chassis. The equipment was approximately 10' high, 5'6" wide and 26' long. It probably weighed around 3 tons. It struck the author as being an extraordinary effort of the Birmingham University Physics Department--being assembled adjacent to an abandoned cyclotron!'

At a subsequent meeting BTH were given authority to make a similar set. It was unclear as to the original purpose of this new set, but it was understood that it was to replace Oliphant's rather scrappy set with a properly designed one, or it was intended to go to ADEE (Air Defence Experimental Establishment) at Christchurch for evaluation. On the basis of the former purpose, BTH named it 'SFO' (Set for Oliphant).

This equipment was authorised on October 9th 1940 and was working and being tested on March 11 1941. It had originally been designed to use an Oliphant Klystron, but these proved to be too temperamental and extremely difficult to set up or to repeat in manufacture, and at the beginning of February, it was decided to redesign the transmitter and modulator to take a GEC Magnetron. By that time an alternative local oscillator valve had been designed by Dr Sutton of the Naval Valve Section of the Admiralty Signal School. The set underwent trials with live aircraft during April and after a partial refit to make all the equipment secure on the Searchlight Chassis, it was despatched to ADEE at Christchurch on May 30 1941, for evaluation and trials. It was accompanied by Dr. J.V. Dunworth, sometime Director of NPL. He set it up at Christchurch on the 31 May, without any difficulty, and tracked an aircraft at 15.00 hours.

The equipment was the prototype for 10 further equipments of this style, intended for RAF use as accurate centimetric height finders. A different cabin enclosed design was used for the GL3 (AA No 3 Mk2) Gun Laying equipment, although the basic circuitry did not change

much, other than to accommodate higher power transmitters. This original set was 10Kw 1 microsecond pulses, at a PRF of 500 per second, uprated to 120 Kw before despatch to Christchurch and later in the year, to 150Kw. (PRF- Pulse recurrence frequency).

The photograph was taken in front of the BTH Research Labs at Rugby on 30 May 1941 just before leaving for ADEE. It portrays Dr Whitely Asst Director of BTH Res Labs (on left). The legs visible in the centre are of Bill Melville, one of the transmitter Engineers.

The whole set was built from nothing in 5 months, from authorisation to testing as a radar. Nobody at BTH had any prior knowledge of radar (or radio even). Most of the men employed were cinema projector and sound engineers.

This is therefore one of the most historic photographs of the Centimetric radar era

(This particular copy, framed, was presented to DHT when he retired from the Royal Signals and Radar Establishment in 1979, by the Engineers by then at Marconi, who had worked at BTH, Rugby and Leicester, and with whom DHT had worked on several Ministry Contracts, from October 1940 to 1978).

SLI 14 Radar Type 82 Radar Head (Framed)

The Radar Type 82 (RAF) was originally intended for the British Army, as a Central Control Tactical Control Radar and called Orange Yeoman, and intended to be AA No 4 Mk 8. It was capable of tracking up to 64 targets and after consideration of tactics, location of attack etc, of transferring data in the form of bearing range and elevation to up to 6 gunnery putting on radars at 6 totally different locations within a defended area. These radars then tracked the target selected more accurately for the purpose of feeding predictors and thence to control the guns. In 1953 AA Command was disbanded and AA Gunnery in UK ceased. The RAF moved to the use of Guided Missiles (SAM 1) and the Orange Yeoman became the tactical control radars for this purpose, fulfilling approximately the same role as intended for the Army. There was an operational radar built as a prototype for the RAF at RAF Northcoates, and 3 production stations at RAF's Lindholme, North Luffenham and Watton.

In 1963 SAM 1 was discontinued, and the radars were redundant, but were eagerly taken up by the RAF Military Air Traffic Control system as ideal for their purpose, with track data production and data handling systems. The remoting of data however was not required.

This photograph shows the Lindholme Radar Head. The aerial consists of a 45 feet long waveguide fed Cosecant² aerial for the transmitter (fed with 2½ Mw of power) and a lens receiver aerial, with a stack of 11 horns, each feeding a separate receiver, and fed to special CRT displays where elevation of specified targets could be determined.

Part of the Tomlin Radar Archive contains a detailed description of the Type 82 (File 37).

SLI 15 Radar Type 82 Control Room (Framed)

(See Photo SLI 14 for brief description of Type 82 Radar)

This photograph shows the Type 82 Control Room at RAF Lindholme, in use as a Military Air Traffic Control Centre (Northern Radar).

The Control system consisted of teams of operators, each Team consisting of a tracker, a height finder and 2 controllers. Each Controller could handle up to 4 aircraft, and each tracker and each height finder kept the tracks of all 8 targets up to date. The group of 3 operators in the immediate foreground are the Senior Controller, Supervisor and Track supervisor (ensuring that trackers kept targets up to date).

Staff Lists

SLEE/ADEE/ADRDE Staff List 1

This is a list of Staff known to have been at SLEE between 1917 and 1922. Many of them were still at ADEE from 1922 onwards to the Second World War.

The Searchlight Experimental Establishment was set up in 1917, using Service Members of the London Electrical Engineers, TA, drawn back from active duties (at Batteries in the forts on the Thames Estuary) to study and rectify problems found in searchlights when they were elevated to scan the sky to locate enemy aircraft. Up to that time searchlights had been used for surface detection of ships. They returned to their TA Headquarters in Regency St, London, to set up laboratories and workshops.

Technical Officer: Capt. J. Payley-Yorke

Personnel: T. Atkinson
 V.G. Chance*
 F. Code
 E.A.H. French *
 Capt. H.C. Gibson•
 H.E. Harris*
 R. Hogg
 F.W. (Pony) Moore*
 A. Price
 J. Taylor
 F. Tye
 J.B. Walker *
 J.Wettel *
 (?) (Blanco) White *

At the end of WWI, those who wished to stay were demobilised 'in situ' and became part of the Air Defence Experimental Establishment in 1922. Some went back to their pre-war jobs. However several of the original members of the SLEE were still at the Establishment into the 1950's. Marked*. 'Pony' Moore became the oldest man in England, living to 109 years.

SLEE/ADEE/ADRDE Staff list 2

This is a list of Scientific Staff at ADRDE in 1944, given in order of groups in which they worked.

Research and Investigation

Hodgkinson T.G. C.S.R.

(Adlington House)

Hinchcliffe A. (Capt.)	T.O. (II)
------------------------	-----------

Hayward W. J.	L.A. (II)
---------------	-----------

Cocks H.V.	L.A. (II)
------------	-----------

Hodges A.W.	L.A. (II)
-------------	-----------

Radio Ballistics (Malvern)

Taylor S.M.	S.O.
-------------	------

Bugler F. R. W.	E.O.
-----------------	------

* Scrivener J.	L.A. (II)
----------------	-----------

Wheeler L.R.	L.A.
--------------	------

Windall R.	L.A. (II)
------------	-----------

*At time on loan to S. of E. (Shoeburyness)

Research & Investigation. Measurements

Head of Group	C.E. Oatley	P.E.O.
---------------	-------------	--------

P.A.	Miss M. MacMahon	L.A.
------	------------------	------

Aerials.

Head of Section	J. Ashmead	E.O.
-----------------	------------	------

E.G. Brewitt Taylor	E.O.
---------------------	------

R. Elson	E.O.
----------	------

A. Maclese	E.O.
------------	------

Miss O.J. MacCarthy	E.O.
---------------------	------

A.B. Pippard	E.O.
--------------	------

J. McA. Reid	E.O.
--------------	------

N.G. Stewart	E.O.
--------------	------

A.E. Fitt	L.A.H.
-----------	--------

D.C.G. Journet	L.A.
----------------	------

U.H.F

Head of Section	D.H.T. Gant.	E.O.
-----------------	--------------	------

Miss F.W. Black	E.O.
-----------------	------

D. Luffman	E.O.
------------	------

L.G. Mead	E.O.
-----------	------

P. Robbins	E.O.
------------	------

R. Street	E.O.
-----------	------

Ditchfield	EA3
------------	-----

Beadle	EA3
--------	-----

H.H. Greenwood	EA3
----------------	-----

M. Yeomans	EA3
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G.B. Matthews	L.A.
---------------	------

Research & Investigation. CA CD Trials

M.V. Wilkes	S.E.O.
R.I.B. Cooper	E.O.
G.A. Rogers	E.O.
W.B. Vanstone	E.O.
H. Shaw	A2
J.Y. Freeman	A3
W.G. Allen	L.A.H.
C.R.N. Barnard	L.A.
Miss H.B. Edmonds	L.A.
R. Holden	L.A.

Cathode Ray Tubes

Miss J.M. Hayden	E.A.
Miss A.R. MacLoughlin	E.A.
F. Gardener	L.A.H.
K. Frampton	L.A.
Miss N. Johnson	L.A.
Miss G.R. Nash	L.A.
D.S. Trudgill	L.A.
G.R. Tyler	L.A.
H. Vowles	L.A.

Instrument Room

C.M. Burrell	E.O.
A. Reading	A2
F.C. Court	A3
P.B.F. Evans	E.A.
Miss S. Hall	L.A.

Library

Miss D. Harper	E.O.
Miss M.E. Lewis	E.A.
Mrs I.L. Eyles	L.A.
Miss J.M. Leyland	L.A.
Miss PM McEldon	L.A.

Receivers

J.G. Yates	E.O.
F.R. Andrews	E.O.
C. Baron	E.O.
K.F. Gander	E.O.
G.W. Fynn	L.A.
J. Bradshaw	L.A.
L.M. Davies	L.A.
H.F. Hull	L.A.
E.J. Jefferies	L.A.
J.B. Kennedy	L.A.
F.A. Linsey	L.A.

Transmitters

M. Snowden	E.O.
R.H. Johnson	E.O.
H. Nichols	E.O.
L. Damon	L.A.
C. Evans	L.A.
H. T. Hammond	L.A.
D.F.S. Shepherd	L.A.

Valves

A.B. Russell	E.O.
Mrs E.L. Fifield	L.A.
R.H. Gwynn Smith	L.A.

Cathode Ray Tubes

J.G. Bartlett	A2
---------------	----

Research & Investigation. Experimental Mechanical Section

H.C. Gibson	S.T.O.
E.R. Williams	S.O.
J.L. Candler	E.O.
S.F. Blunden	A2
V.G. Chance	A2
R.J.V. Chappell	A3
G.E.P. Evans	A3
H.W. Sanders	A3
R.C.B. Channon	E.A.
D.S. Bray	L.A.
R.G. Davis	L.A.
V.J.G. Ibbett	L.A.
W.G. Jarman	L.A.H.
C.A. Jones	L.A.
W.G. Marsh	L.A.H.
F.E. Youngs	L.A.

Fuzes

P. Rothwell	P.S.O.
PA Miss D.P. Whitaker	L.A.

Electronics (British)

D.C. Stenning	E.O.
A. Ashmore	E.O.
D.L. Allen	E.O.
H.F. Harrison	E.O.
S.E. Shapcott	E.O.
F.G. Endersby	E.A.
J.R. Evans	E.A.
Miss J. Southern	E.A.
P.J. Parker	L.A.
P.A. Woodhams	L.A.

Modifications (American)

A.F.H. Thomson	S.O.
C. O. Gottlieb	(Can)
P.E. Lashler	(Can)
M. Ruhinoff	(Can)

Electrical & Mechanical

F.A. Cunnold	S.O.
F.W. Holmes	E.O.
W.C.G. Slatter	T.O.
F .H. Birkett	CIEME
P.W. Groom	L.A.
G.A. Gibbons	L.A.
E.J. Johnson	L.A.
N.A. Parker	L.A.

Design & Production

N.J.H. Lemmon	Group Co.
R.E. Dawson	

Research & Investigation

TRIALS

E.S. Shire	S.E.O.
PA Mrs E.A. Snowden	E.A.

Trials AA

R.H. Ferguson	T.O. (B)
P.H. Blundell	E.O.
W.G. Merriman	E.O.
E.H. Coppinger	A2
C.G. Hurden	A2
N.R. Bailey	E.A.
C.H. Alsop	E.A.
Mrs R. Boulton	L.A.
D.W. Draysey	L.A.
R.R. Moran	L.A.
F.D. Weedon	L.A.
? Heasyman	Mechanic
? Shepherd	Labourer
?Jones	Labourer

Control Systems

Dr. A. Porter	S.O.
E.A. Johnson	E.O.
Miss B.A. Langford	E.O.
Col. Sozymanski	E.O. Polish
G. C. Simpson	L.A.
Lt. Hughes	Mil

Training Methods

G.F. Clarke	T.O.
W.N.P. Court	E.O.
G.C. Hanna	E.O.
P.M. Milner	E.O.
G.V. Stupart	E.O.
R.W. Holmes	E.O.
A.J. Barton	L.A.
H.F. Cowell	L.A.H.
R.G. Davies	L.A.
G.W. Pitsey	L.A.H.
D. G. Sills	L.A.

Ancillary Sections, Assembly

G.R. Newbery	E.O.
A.H. Allen	L.A.H.
E. C. Cuthbertson	L.A.
J.W. Hazell	L.A.H.
F.H. Jessop	L.A.H.
A.T. Johnson	L.A.
E.F. Miller	L.A.
? Medhurst	Mechanic

Auxiliary Problems

A.F. Phillips	E.O.
L.R. Whittle	L.A.

Maintenance and Construction of Electrical Apparatus

E.F. Good	E.O.
C.P. Lea Wilson	E.O.

Field Trials (Beckhampton Range)

M.W. Fulkes-Roberts	T.O.
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Field Trials (Ynyslas Range)

K. Wilson	E.O.
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Modifications

G.L.S. Burrows	CIEME
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Fuze Stores

J.H. Walker	A2
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Reporting

Miss B. Richens	E.O.
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Detached at Hivac Ltd

A.R. Rangabe	E.O.
R.F. Day	L.A.H.
E.S. Shire	Cont.

Theory

J.M.C. Scott	S.O.
N. Corcoran	E.O.
C. Mack	E.O.
T. Pearcey	E.O.

Lt. C. Randers	E.O. Norway
Miss M. Long	E.A.
Mrs M. Tomlin	E.A.
Miss F. Whitehead	L.A.
G.R.	
E.C. Slow	S.O.
E.N. Martin	E.O.
J.W. Pletts	E.O.
S.W. Baker	E.A.
P.G. Briggs	E.A.
J. T. Stringer	E.A.
W.T. Laite	A2
D.F. Cooper	L.A.
? Lawrence	L.A.
S. Nash	L.A.
G. C. Wilson	L.A.
Lt. Hayes	M.
? Heath	M.
Proofing	
Lt. J.M. Hutson	
Sgt. M. Ladbrooke	M. R.A.
Gnr. F. Hilton	M.

Addenda

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Vol. 10 no. 2- (June 2005-)

Photograph of Donald H. Tomlin (B&W)

Audiocassette of the speeches made at the Inauguration of the University of Sheffield Radar Archive, 21st October 2005

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